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THE NEW ORLEANS SEWERAGE CASE has been decided by Judge Ellis against the Sewerage and Water Board by decreeing a perpetual injunction against the compromise proposed by the board. Judge Ellis, in reviewing the case, says that the franchise of the New Orleans Sewerage Co. has expired by reason of its abandonment of the work in 1895. He says that the board has power to appropriate the work done by summary process, and that the $304,173 which the board had agreed to pay the company was largely in excess of the value of the work done. He treats lightly the claim of the board that this sum represented, in addition to the work, an offset to very possible long legal delay and heavy costs in connection with a much-needed public work. The board will appeal to the Supreme Court, and the feeling in New Orleans seems to be that an unfortunate precedent is being set in permitting one or two taxpayers to indefinitely obstruct the conduct of a good public improvement.

A CREMATORY FOR THE PAUPER DEAD has been recommended by Mr. Francis G. Ward, Commissioner of Public Works, Buffalo, N. Y. A similar recommendation was made by the city officials of Boston in 1899 and subsequently. At Buffalo, as at Boston, the Potter's Field is overcrowded. It is estimated that the cost of cremation would be only $1 per body, against $3 for burial.

PURER WATER FOR CHESTER, PA., has been ordered by a judge in a trial court. The judge declares that the New Chester Water Co. has "refused and neglected to furnish the plaintiffs and its patrons with a sufficient supply of reasonably pure and wholesome water," and gives the company ten days, if no exceptions are filed, to take steps to introduce a new supply or purify water from the present source.

A RESERVOIR DAM OR EMBANKMENT near Connellsville, Pa., failed on May 20. The reservoir formed a part of the water-works of Connellsville, owned by the American Water-Works & Guarantee Co., of Pittsburg, Pa. The company made a statement to the press, from which it appears that the reservoir was subsidiary to the main storage reservoir, and that it had a capacity of about 12,000,000 gallons. A breach in the dam 100 ft. long was caused by a cloudburst, the company states. The reservoir then contained about 22 ft. of water, and the breach lowered this by 10 ft. The full depth of water is given as 25 ft.

WATER RATES AT BURLINGTON, VT., will hereafter be less than one-half, for the majority of water takers, what they were 14 years ago. The charge for a single faucet for family or office use is $6 a year, and for a water closet or bathtub $4 additional. The meter rates, however, range from 15 to 6 cts. per 100 cu. ft., or from about 20 to 8 cts. per 1,000 gallons. The minimum meter charge for metered water is $1.50 per quarter, but the annual charge must not exceed $6 for 4,000 cu. ft. or less. In other words, domestic consumers are entitled to 30,000 gallons of water per year, or a little over 80 gallons per tap per day for the minimum charge. This charge is identical with that for a single faucet, but with tight plumbing a family with a meter may enjoy several additional fixtures without exceeding the minimum charge. Mr. F. H. Crandall is superintendent of the Burlington water-works.

THE DEPRECIATION OF GAS PLANTS, according to an article by Mr. R. W. Prosser in the "American Gas Light Journal" for May 26, may be figured on the following basis of years of life in actual or practicable service: Cast-iron mains, 70 years; buildings and foundations, 40; brick tanks, gasholders, steel tanks and holders, benches, condensers, scrubbers, purifiers and consumers' meters, 30; station meters and governors, engines, service pipes, water gas apparatus, including generators, superheaters and wash boxes, 25; pipe connections and valves, 20; boilers, pumps and piping, 15 years. With the exception of buildings, brick tanks, benches, service pipes and consumers' meters, Mr. Prosser believes that when the exigencies of business demand the replacement or displacement of the various parts just named they will still have some value, ranging from 5% of their original cost for gas-holders to 33% for pipe connections and valves. On the basis outlined, the depreciation of a coal gas plant, allowing 4% compound interest on a sinking fund, would amount to about 3 cts. per 1,000 cu. ft. of gas sold.

A CARD INDEX TO GAS LITERATURE is being made by the Library Committee of the Western Gas Light Association. Subscriptions of $10 to $50 per year are requested, graded on the gas output of the subscribing company. Besides the subject, exact title, author and length of the articles indexed, the cards will indicate the nature of the articles, whether illustrated or not, and the volume, page and date of each of the leading journals in which it appeared.

PLACING TELEPHONE WIRES in underground conduits carrying high tension electric wires has been held by a court referee at Rochester, N. Y., to be sufficiently dangerous to warrant the court to refuse to enjoin the Bell Telephone Co. from constructing an independent conduit in that city. The city tried to compel the company to place its wires in conduits built by the Rochester Gas & Electric Co., under a city contract providing for joint use of the conduits by all companies having electric wires, and also providing that the city may own the conduits at any time by paying the cost of construction. The referee heard about one hundred witnesses in Rochester and other important cities. We are indebted to Mr. Edwin A. Fisher, M. Am. Soc. C. E., City Engineer of Rochester, for the information on which this note is based.

A SPECIAL TROLLEY CAR FOR CONVEYING FIRE engines is in use at Springfield, Mass. The engine is carried on a platform only 9½ ins. above the top of the rail, mounted on a truck at each end. The front truck is detached and the front end of the platform lowered to the ground when the engine is to be loaded on the car. Platforms over each truck afford space for firemen and equipment. The length of the car over all is 30 ft. 10½ ins., and its net weight is 14,000 lbs. The Springfield Fire Department has loaded an engine on one of these cars in 2¾ minutes from the time the car was in position to its being ready to start, and has unloaded an engine and attached the horses to it in 1¾ minutes. The car was built by the Wason Mfg. Co., of Springfield, Mass.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a freight train on the Western Pennsylvania division of the Pennsylvania R. R., near Blairsville, Pa., on May 27. The engineer and the fireman were killed. The wreck is said to have been caused by the breaking of a wheel flange on a curve.

ANOTHER MINE DISASTER has occurred, this one at Fernie, British Columbia. On the evening of May 22, soon after the night shift went on, an explosion occurred in the Coal Creek Mine, belonging to the Crow's Nest Pass Coal Co. There were over 150 men in the portion of the mine reached by the explosion, and only about a score of these escaped alive.

A WATER TANK FAILURE at Sheffield, Ala., is reported as having occurred on May 20. The tank had a capacity of 90,000 gallons, was of cypress, and rested, it is said, on a tower 60 ft. high. Press dispatches state that the tank had been leaking for some time. The water-works are owned by the Consolidated Water & Light Co.

MUNICIPAL CIVIL SERVICE EXAMINATIONS will be held at 346 Broadway, New York city, on June 2 for civil service examiner in mechanical engineering, and on June 9 for architectural draftsmen. The compensation attached to the position of civil service examiner is at the rate of $10 per session while employed, seven hours constituting a session. Candidates should be experienced mechanical engineers. Candidates may be examined as to their ability to prepare suitable questions and to rate the answers to the questions given for the various positions in the city service requiring mechanical knowledge. The work required in the preparation of the questions and rating of answers to same does not necessitate attendance at the office of the commission. The position, which covers the lowest grade of architectural draftsman, is of the apprentice class, corresponding to the position known as "Junior Assistant Architectural Draftsman." Those passing the examination will be eligible to appointment at $750 per annum, or less. Vacancies at present exist in the Building Bureau of the Department of Education at salaries of from $8 to $12 per week.

PROGRESS ON THE SIMPLON TUNNEL during April, 1902, is reported as follows: The advance of both headings during the month was about 500 ft., of which only 46 ft. in the south heading. This bring the total advance of headings up to the end of April to 37,671 ft., of which 14,619 ft. is at the south end and 23,052 ft. at the north end. The north heading encountered a short section of horizontally stratified slate bearing large amounts of water, where heavy timbering was required. This was, however, soon succeeded by compact slate rock. The south heading is still in disintegrated calcareous schist, but the amount of water in the rock is decreasing. Hand drilling is still continued here, and steel ribs, spaced 24 to 48 ins. centers, are used for the lining, with concreting between and around them.

DEFECTIVE WELDING OF BOILER TUBES may be readily detected by chemical means, according to a communication by Mr. D. Woodman before a joint session of chemical societies at the Chemists' Club, New York, on May 23. A certain lot of boiler tubes had given very poor results, corroding to failure very rapidly; another lot subjected to precisely similar conditions had been satisfactory. Submitted to Mr. Woodman for analysis, he found them to be of practically identical material—a fair quality of wrought iron. It was then suggested that possibly differences in the welding might have something to do with the behavior of the tubes. This was tested by laying sections of each kind of tubes in 10% sulphuric acid. The good tubes were attacked uniformly all around, the line of the weld showing merely by its color. The other tubes, however, were eaten away on the line of the weld very rapidly, so that a deep slit was formed there. This indicated that the metal along the weld was porous and open; in other words, that the weld was imperfect.

A 1,836-TON RAILWAY BRIDGE was moved by the engineers of the Pennsylvania R. R. on May 25 to a position 14½ ft. to one side of its original location, alined and connected to the new tracks in eight minutes. The bridge is located at New Brunswick, N. J., and consists of five fixed spans crossing the Raritan River and one draw span crossing the Delaware & Raritan Canal. The total length of the structure is about 900 ft. Jacks were used to start the structure on its sidewise journey, after which it was hauled by seven stationary engines suitably located on the shore and at the ends of the temporary piers. From the moment that power was applied to the jacks until the 14½-ft. journey was completed the time was 1 min. 43 secs. To aline the structure in its new position took 2 mins. and 55 secs., and in 8 mins. from the start the bridge tracks had been connected to the shore tracks and the structure was ready to carry trains. The stone-arch bridge which will be built on the former site of the bridge which was moved was described in our issue of Jan. 30, 1902.

A 20-K-W. ALTERNATOR, OPERATED BY A PELTON water wheel, receiving its water from the delivery side of the main pumping engine, is a novel feature of the electric plant of the water-works of St. Louis, Mo. This electric plant is an adjunct of the water-works plant, and furnishes current for the municipal railway extending from the Baden Pumping Station to the Chain of Rocks and for lighting the several buildings belonging to the Water Department and located in a distance of about five miles along the Missouri River. The generating set of the plant comprises a 100-K-W. railway generator and one 100-K-W. and one 20-K-W. alternators for electric lighting. The railway generator and the larger alternator are driven by engines, but the smaller alternator is direct-connected to a Pelton impulse wheel supplied from the mains and running at 1,200 r. p. m. In defense of this roundabout method of transmitting the power, it is pointed out that the efficiency of a large pumping engine is high, while that of so small a steam engine as 20 K-W. would be low. In fact, it is stated that tests have shown that the Pelton water wheel is so efficient that this generator is operated on a total steam consumption of about 30 lbs. per electrical horse-power-hour, which is probably much less than could be obtained with so small a unit by direct connection to an engine. The principal advantage of the water wheel drive, however, is in the matter of first cost, a water wheel costing much less to install and requiring less care than an independent steam engine of the same capacity.

CONCRETE BREAKWATER CONSTRUCTION AT BUFFALO, NEW YORK.

By T. W. Symons,† M. Am. Soc. C. E., Major, Corps of Engineers, U. S. A.

During the last century, when the necessity for breakwaters at some of the lake harbors became recognized, the only ones in existence throughout the world were those of stone and masonry, costing from $500 to $1,500 per lineal foot. Such expensive structures were beyond the financial resources of our people at the time.

With true American adaptiveness, however, another type was designed of far less cost, which has done good service. This was composed of a row of timber cribs sunk in place, filled with stone, and surmounted by a continuous superstructure of timber filled with stone and decked over with planking. The cheapness of timber, and the fact that these structures were built in fresh water and free from the ravages of the teredo and other destructive marine insects, justified the character of the structures. In the aggregate a large amount of this general type of structure has been built at the lake ports.

In such structures there are two distinct features—the substructure, or part below water, which, on account of the preservative properties of fresh water on wood, has a very long but indefinite life, and the superstructure, the part above water, the wooden portion of which, being exposed to the action of the elements, decays with greater or less rapidity. This superstructure is also exposed to the physical destructive action of waves, ice, boats and vandals, and requires constant repairs, and, finally, when sufficiently weakened by decay, complete renewal.

In several instances on the lakes where this renewal has been found necessary it has been done by substituting a concrete superstructure for the old wooden and stone one.

The first fully exposed wooden and stone breakwater to be built on the Great Lakes was at Buffalo, and at Buffalo was also built the first concrete superstructure to replace the old wooden one which had become dangerously weakened. This was done under the direction of Capt. F. A. Mahan, Corps of Engineers, and consisted of solid concrete, conforming generally to the shape of the wooden superstructure which it replaced. Concrete blocks were used about the water's edge. A cross-section of this breakwater as constructed is shown in Fig. 1. The heart was of natural cement concrete, the exposed portion of Portland cement concrete. During the years 1887 to 1891, 3,878 lin. ft. of this solid concrete superstructure was built.

†U. S. Engineer Office, 540 Federal Building, Buffalo, N. Y.

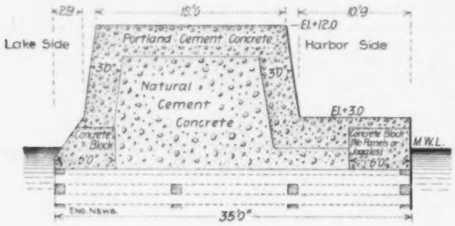


Fig. 1. Typical Cross-Section of Old Concrete Superstructure for Buffalo Breakwater; 1887-1891.

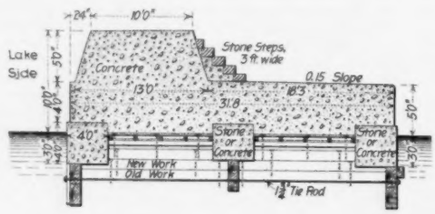


Fig. 2. Typical Cross-Section of Concrete Superstructure for West Breakwater, Cleveland Harbor.

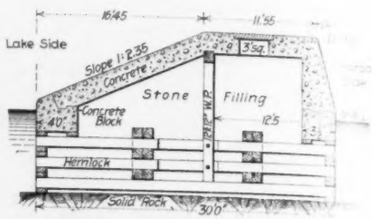


Fig. 3. Typical Cross-Section of Concrete Shell Superstructure for Dunkirk Breakwater.

For some years past the work of replacing the superstructure of the Cleveland, O., breakwater with a solid concrete superstructure has been and still is in progress. This work was designed by Col. Jared A. Smith, of the Corps of Engineers. A cross-section of this superstructure as built is shown in Fig. 2.

A wooden breakwater with a concrete superstructure may properly be considered as a permanent structure, reasonably secure against decay and deterioration. The question therefore naturally arises, why not put the concrete superstructure on at first? The answer is that most of the lake breakwaters are built on the ordinary lake bottom of clay and sand, and for some years after they are completed settlement and displacement occur, which are generally of unequal character in different portions of the structure. Nearly all wooden breakwaters, piers, etc., present a wavy appearance, due to this unequal settlement and displacement. The wooden superstructure adapts itself to this without serious harm, but a rigid superstructure of masonry would be very seriously injured by it, rendered very unsightly, and perhaps be completely ruined. By the time the wooden superstructure has rotted off the whole structure will have reached its final settlement and be in a condition of permanent stability and fitted to receive its rigid concrete superstructure.

An exception to the general system of consecutive construction as outlined above is where the new breakwater is founded on rock or other bottom of sufficient rigidity. Such is the case in two points in the district under my charge. At Dunkirk, N. Y., an extension to the wooden breakwater was built by me in 1898, and as it could be founded upon the rock bottom, it was built in the first place of timber crib filled with stone, with a concrete superstructure. Fig. 2 is a section of this breakwater, which has the distinction of being the first concrete shell breakwater superstructure to be built on the lakes or elsewhere, as far as I know.

The second point where a new breakwater was built with timber and stone substructure and concrete superstructure was at Buffalo, at the northern portion of the harbor, where rock foundation also existed. The concrete shell superstructure surmounting this breakwater is similar in all material respects to that illustrated as used in putting a new superstructure on 1,015 ft. of the old breakwater at Buffalo.

When a portion of the old breakwater at Buffalo received a new concrete superstructure, in 1887-91, a section of 1,015 ft. was left in its original condition, because it was deemed that the substructure was not in a sufficiently stable condition to receive the concrete superstructure. This was finally remedied by dumping and placing large amounts of waste stone along its [illegible] side, and during the years 1899 and 1900 [illegible] put into a permanently good condition by building upon it a concrete shell superstructure [illegible] had to be made to fit the existing cribs, which [illegible] owing to serious trouble when the breakwater was built, were sadly out of shape. The ordinary [illegible] the maximum cross-sections of the superstructure as built is shown in Fig. 4.

During the fall of 1900 the new [illegible] crib breakwater near Stony Point was badly wrecked by the tail end of the great Galveston storm, which, sweeping up through the Mississippi Valley, paid Buffalo a visit on its way to the North Atlantic, and by a more severe storm about six weeks later. The substructure of the breakwater, the cribs, was uninjured, but it was found to be necessary to replace about 1,800 ft. of the superstructure. Several plans were made for rebuilding this superstructure—with wood and stone, with large quarried stone, and with concrete. The following considerations led to the final selection of the material and design adopted for the new superstructure:

(1) The locality requires excessive strength, as, owing to its being right on the axis of the lake and in the deepest water, it is subjected to stronger wave action than at any other point along the lake front of Buffalo.

(2) The structure had been well pounded down by the waves so that it could be considered to have reached its final settlement, unless its weight was greatly increased. It was therefore in a condition to receive a concrete superstructure.

(3) The exposed condition of the substructure demanded that the superstructure be added with the least possible delay.

(4) If the new superstructure was built of timber and stone, it would have to be built stronger than before and would require much more and heavier timber. As the cost of timber had enormously increased of late, and as the settlement of the whole structure did not demand the use of timber, it was deemed unwise to use it

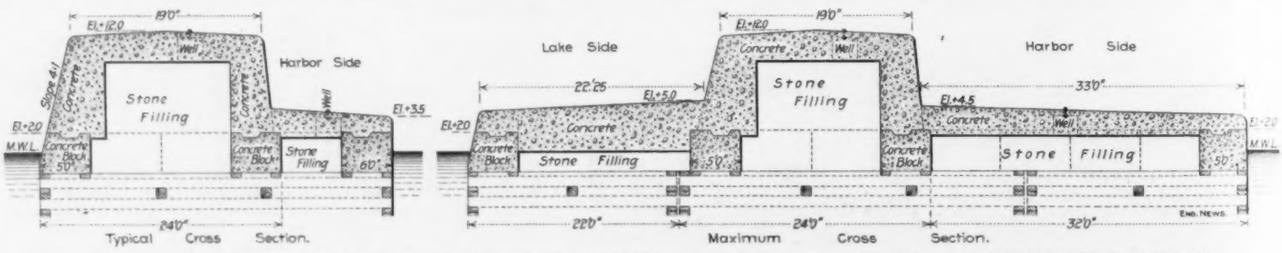


FIG. 4. MAXIMUM AND TYPICAL CROSS-SECTIONS OF CONCRETE SUPERSTRUCTURE FOR OLD BREAKWATER, BUFFALO.

(5) A good superstructure could be built of large stone from the Canadian quarries and at a comparatively low cost, but it was found that the work could not be done under two years at least. It was considered too dangerous to leave the damaged work unfinished for that length of time.

(6) Contractors were willing to undertake to put a concrete superstructure on the wrecked portion in one working season, and this was finally decided on, and the work was carried on during the whole working season of 1901.

As this is the latest concrete superstructure to be built, and as it represents the latest and best practice and the wisdom gained by experience on

several other similar works, both by the engineers and contractors, it is here quite fully described.

The adoption and development of the concrete shell type of breakwater superstructure is regarded as important. It has all the advantages in weight and strength of a solid concrete superstructure at a greatly reduced cost. By varying the size of blocks and thickness of walls and decks and general outline, it can be adapted to locations with different and varying exposures and with great ultimate economy. On account of the high price of timber nowadays and the low price of cement, a concrete shell superstructure can ordinarily be built at a cost no higher than a wood and stone superstructure, and wherever conditions as to foundation and settlement can be met, it should be adopted in the future.

It seems proper to state that of the 12,800 ft. of new breakwater at Buffalo, 7,260 ft. is to be of stone and gravel, as described in Engineering News of May 16, 1901, while the remainder on each side of the new south entrance was built of timber and stone. This was done largely that vessels might have mooring facilities near the entrance. The stone breakwater was not adapted to this.

The portion of the timber crib breakwater which was wrecked is that lying to the north of the entrance, and which will abut end to end with the stone breakwater when the latter is finished, and is known to us as the South Harbor Section of the work. In this portion of the work, the substructure, or part below water level, as originally constructed, consists of timber cribs filled with rubble stone and founded on an artificial foundation consisting of a layer of rubble stone about 8 ft. high, resting on a bed of gravel from 30 to 40 ft. deep, which was backfilled into a trench excavated to bed rock. The cribs were so sunk that their tops were practically at the level of mean lake water. This substructure has a length measured along the line of the lake face of 2,739 ft. There are in all 16 cribs, one short crib and 15 long ones. The short crib, which is located at the south end of the structure, is 60 ft. long, 36 ft. wide and 22 ft. high, and is placed with its longer length at right angles with the axis of the structure, and thus extends 24 ft. inside the general harbor line. This acts as a buttress and an emplacement for a lighthouse which is to be built on it. The longer cribs are each 180 ft. long, 36 ft. wide and 22 ft. high. The original alinement of these cribs was almost perfect, the extreme variations from a straight line not exceeding more than a few tenths of a foot.

Resting upon this substructure of cribs was a superstructure of similar construction to the cribs and also filled with rubble stone. The superstructure was built in five sections, the first having a length of 576 ft., the other four being in nominal lengths of 540 ft. each. It consisted of a banquette, a middle deck, and a parapet, each 12 ft. wide, and at elevations of 6, 10 and 12 ft., respectively, above mean lake level, the highest part being next to the lake. This is plainly shown on the accompanying photograph, Fig. 5.

The structure was finally completed on October 27, 1900. It had suffered great damage from the gale of September 12, 1900, and still greater damage from that of November 21, 1900. This last gale was of unusual violence, the wind blowing at times at the rate of 80 miles per hour from the west. The water level at six o'clock in the morning of this day was 2 ft. below mean lake level; at noon it was 1 ft. above; at 4 o'clock in the afternoon it had reached a point 6.4 ft. above; and at midnight it dropped down to 3 ft. below mean lake level, a wind-produced variation in water level of 9.4 ft. in about 8 hours.

During this gale—it might more properly be called a hurricane—tremendous seas broke over the breakwater. The waves dashing against the vertical walls of the structure rose to a great height above it, variously estimated at from 75 to 125 ft., enveloping the breakwater in an immense sheet of water, which in falling struck the top of the superstructure with such force as to crush in the same, the large timbers of which it was constructed being broken like pipe stems (see Fig. 6). The direction of the breakwater being at right angles to the axis of the storm tended further to accentuate the destroying power of the furious waves.

When it came to the question of reconstructing this superstructure it was decided that concrete masonry was the material best adapted to enter largely into its construction. The facility with which this material can be made and shaped into monolithic masses is a great point in its favor. When it was decided to replace the wrecked superstructure with one of concrete, it was considered expedient to disregard the usual practice of presenting a vertical face to the sea, but instead, adopt a sloping face, with a view of reducing the impact of the waves, the idea being to reduce the height of the impelling water by translating its movement from nearly vertical to an inclined direction, thus allowing the water to pass over the structure in a flowing mass without detriment to the same. The proper slope for the lake face that was believed to best attain this desideratum was fixed at 1½ on 1, corresponding to an angle of 33° 41′ from the vertical. The cross-section adopted is fully shown on the accompanying drawing, Fig. 7.

The lake side is vertical for nearly 2 ft., then slopes from the mean lake level to a height of 11.5 ft. above the same, broken only by a narrow berme 0.75-ft. wide, at the height of 3 ft. above mean lake level. This berme was designed to facilitate the placing of the forms or molds for the mass concrete above the blocks, and is of great value, as the projecting blocks shield the molds from the action of the waves to a marked degree. The front face on outer slope rises 5.42 ft., with a slope of 1½ on 1.

Above this outer slope there is a rise of 1 ft. in 8 ft., half the width of the parquette, then a corresponding fall in the same distance towards the harbor side.

The harbor side presents a vertical face 6 ft. high, beginning at 2 ft. below mean lake level and rising to 4 ft. above. Then there is a rise of 1 ft. in 8.33 ft., this slope forming the banquette deck. The slope rising from the banquette to the parapet is 2 on 1. The cross-sectional area is 374.66 sq. ft., of which 72 sq. ft. is below mean lake level, and 302.66 sq. ft. is above this elevation.

The superstructure consists essentially of three main parts, viz.: (1) Semi-submerged large concrete blocks, serving as a foundation and resting on the top of the stone-filled timber cribs with their bases 2 ft. below mean lake level. The blocks are made in the open, and afterwards placed in position. (2) concrete in situ, and (3) rubble stone filling.

The use of the concrete blocks obviates the necessity of laying concrete under water, a very objectionable method of working, and to be avoided wherever practicable, especially where, as in breakwater construction near the water level, the water is ordinarily subject to violent fluctuations and is always in a state of commotion. A monolithic character is given to the blocks by the fact that on their abutting ends they are provided with joggle recesses which are filled with concrete after the blocks are placed, forming a dowel to prevent the blocks slipping by each other and the water washing through the joints. They were also made with sunk panels in the tops, which aid in more fully uniting them to the concrete made in place above them.

The superstructure is divided into a parapet and a banquette. The parapet, which is on the lake side, covers a width of 27.67 ft. of the cribs along the lake, and is 12.5 ft. high above mean lake level; the banquette covers the remaining 8.33 ft. of the width of the cribs behind the parapet. The banquette is uniformly 4 ft. high above mean lake level at the harbor face. The large concrete blocks are partly below and partly above water, the lower parts thus forming a subaqueous foundation. The concrete in situ is molded to the prescribed slopes and founded primarily on these blocks, and secondarily on the rubble stone filling of which the interior is formed, Fig. 5.

FIG. 5. JUNCTION OF TIMBER CRIB SUPERSTRUCTURE AND CONCRETE SUPERSTRUCTURE; SOUTH HARBOR BREAKWATER, BUFFALO.

FIG. 6. TIMBER SUPERSTRUCTURE WRECKED BY STORM.

The superstructure consists of isolated sections each practically 36 ft. in length, which linear length was determined by making five sections to each 180-ft. crib. By this arrangement the joints of the superstructure and those of the cribs coincide, making them to some extent independent of one another, but not wholly so, as the cross wall blocks cover the joints, resting equally on adjoining cribs. The quantities of material entering into a 36-ft. section are theoretically as below:

Concrete blocks, cu. yds.	109.12
Concrete in place, cu. yds.	234.78
Total concrete, cu. yds.	343.90
Rubble stone filling, cu. yds.	154.44

In detail the construction of an individual section consists of three longitudinal rows of concrete blocks, a lake face row of five blocks, a harbor face row of three blocks, and an interior row of three blocks. The ends of each section are closed by two blocks, connecting the lake face and interior rows, and by one block connecting the interior and harbor face rows. It may be stated here that this latter block was made in place in the work, for the reason that the superstructure as constructed was not uniformly 36 ft. wide, but generally exceeded that width. The excess width

was universally made in the banquette deck, and the distances between the harbor face blocks and the interior blocks being somewhat indeterminate before construction, it was not considered feasible to manufacture blocks of so many different lengths, the result being that these particular blocks were made in place, as above stated. They were well protected by the other blocks against wave action. As stated, all manufactured blocks were made with sunk panels on the top, and all lake face and harbor face blocks were made with joggle channels on the end faces. All blocks were further provided with iron (steel) eye-bolts for handling. The volume of each lake face block is 9.45 cu. yds., having an estimated weight of 18.90 tons. These blocks extend from 2 ft. below to 3 ft. above mean lake level. The harbor face blocks are true parallelopipedals. They are 12 ft. long, 4.5 ft. wide and 4 ft. high. The volume of each block is 7.64 cu. yds., having an estimated weight of 15.28 tons. These blocks extend from 2 ft. below to 2 ft. above mean lake level.

The interior wall blocks are of the same dimensions as the harbor face blocks. The joggle channels at the ends are omitted, which increases their volume to 7.75 cu. yds., having an estimated weight of 15.5 tons.

The parapet cross-wall blocks are 7 ft. long, 6 ft. wide, and 4 ft. high, with a volume of 6 cu. yds., the estimated weight being 12 tons. The blocks extend from 2 ft. below mean lake level to 3 ft. above in the case of the lake face blocks, and to 2 ft. above in the case of the harbor face, interior and cross-wall blocks. All blocks are laid in position on the razed cribs, the timbers and stone filling being properly leveled to receive them.

The space enclosed by the lake face, interior wall and end cross-wall blocks is filled with rubble stone to the grade of 2 ft. above mean lake level, while the space enclosed by the interior harbor face and interior wall and cross-wall blocks is filled with rubble stone to the grade of 1 ft. above the same datum.

The banquette consists of the row of harbor face blocks, the stone filling between the blocks and the interior wall blocks, and a concrete deck ranging from 2 to 4 ft. in depth or thickness, resting upon the concrete blocks and stone filling. The parapet consists of four walls, a front and a back wall, and two end walls. The front wall rests partly on the lake face blocks and partly on the interior rubble stone filling. Its thickness at the level of the top of the concrete block is 7.5 ft., its height above the same point is 5 ft. The thickness on top is 4.17 ft. The back wall rests upon the interior wall block, is 6 ft. high, and its greatest thickness is 5.67 ft. The cross-walls, which rest upon the cross-wall blocks, connecting the front and back parapet walls, are 3 ft. thick, 11.75 ft. long and 6 ft. high. Each row of cross-wall blocks supports two adjacent cross-walls. At the junction of two cribs the cross-wall blocks cover the joints between them, overlapping each 3 ft.

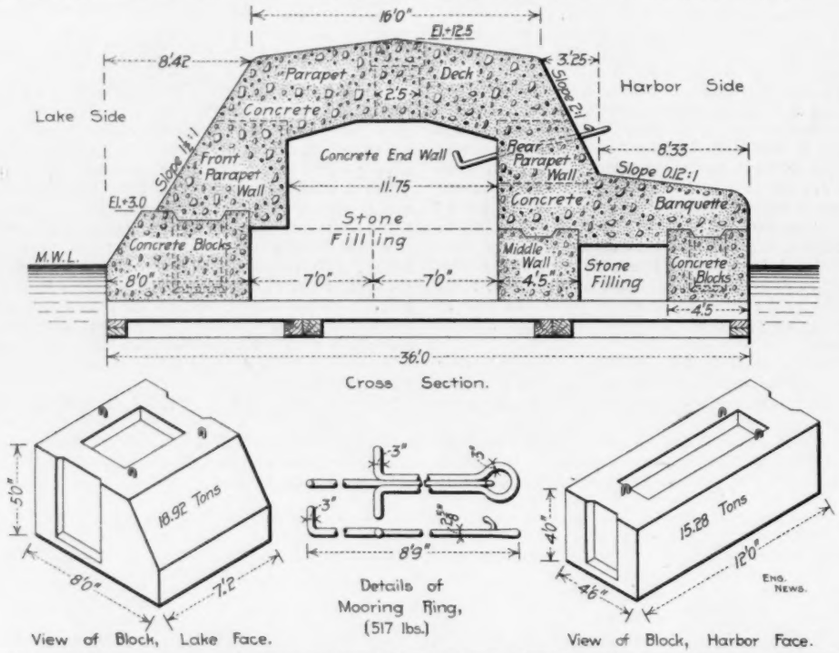


FIG. 7. TYPICAL CROSS-SECTION OF CONCRETE-SHELL BREAKWATER FOR REPLACING TIMBER SUPERSTRUCTURE WRECKED BY STORM AT BUFFALO, AND ISOMETRIC VIEWS OF FACE BLOCKS.

The space enclosed by the parapet walls and end walls is filled with rubble stone, reaching to the level of the top of the walls at the center, and kept 1 ft. below them at the sides, the outline rudely approximating that of a segment of a circle. The whole is covered with a concrete deck 4.5 ft. thick at the center, and 3.5 ft. thick at the sides, resting upon the concrete walls and interior stone filling. Each section is provided with a manhole placed in the center of the parapet deck. These manholes are 2.5 ft. in diameter, with a depressed enlargement at the top 3 ft. in diameter and 1.5 ft. deep, into which a concrete cover of practically the same dimensions is fitted. The object of these manholes is to afford access to the interior of the work, allowing the rubble stone filling to be replenished in case there should be any settlement. The manholes also serve as vents, allowing the compressed air generated by the action of the rising and falling waves to escape, each cover having three large holes for this purpose.

The procedure of constructing the concrete superstructure is as follows: The damaged timber superstructure with its accompanying rubble stone filling above the crib level is first removed, after which the top timbers of the cribs are brought to a uniform elevation of 2 ft. above mean lake level. Any deficiency in the rubble stone filling of the cribs is also supplied. Upon this prepared foundation the blocks for the different longitudinal and cross-walls are next placed, together with the rubble stone filling between them. The joggle channels are filled with concrete as soon as practicable after the blocks are placed. All the concrete work above the blocks is above ordinary water level and is built in the following sequence or order in each section:

The banquette and lower section of the back parapet wall are first built, this part containing theoretically 54.55 cu. yds. The parapet walls are next constructed. This includes the upper section of the back parapet wall, the required volume of concrete being 81.04 cu. yds. The remainder of the stone filling is next placed, followed by the parapet deck, which contains 99.19 cu. yds., the total mass concrete being thus 234.78 cu. yds.

CONSTRUCTION OF CONCRETE BLOCKS.

All the concrete blocks, except the banquette cross-wall blocks, which were made in place, were manufactured on a pile dock, especially constructed for this work in the shallow water of Lake Erie, just off the shore at Stony Point, and protected by the Stony Point section of the new breakwater. The quarters of the contractors' employees were located on shore, access to the same from the concrete dock being effected by means of a plank walk supported on a staging of light timbers. The water at the site of the concrete dock is about 7 ft. deep, and the floor of the dock is about the same height above water level. The dock consists of 10 parallel rows of piles driven from 3.5 to 4 ft. apart in the rows. The piles of the two outer rows are spaced 8 ft. c. to c., while the spacing of the remaining eight rows is somewhat less and irregular, being dependent upon the superimposed load, which is variable.

The piles are capped with 12 × 12-in. timbers placed longitudinally or parallel with the longer axis of the dock. The floor, which forms the bottom of the block molds, is made of 1¾-in. planed plank, tongued and grooved, and of 10 to 12-in. widths placed transversely. The mixer is located in the middle of the dock on one side, while the derrick used for hoisting the concrete ingredients is located on the opposite side. Running the entire length of the dock and equidistant from each side are two tracks of 20 ins. gage. The tracks are spaced 15.8 ft. c. to c. At the mixer they are

FIG. 8. VIEW OF CONCRETE BLOCKS IN PLACE FOR BREAKWATER SUPERSTRUCTURE.

connected by means of a transverse track and a transfer table. The tracks are supported on trestles about 5.5 ft. high, made of light scantlings set upright. The outer faces of these uprights are boarded up with 1¾-in. plank placed horizontally, and which also form one side of the concrete molds. The remaining parts of the molds consist of detachable sides and ends, held together

FIG. 9. PARAPET WALLS READY FOR PLACING DECK. CONCRETE PLANT IN POSITION.

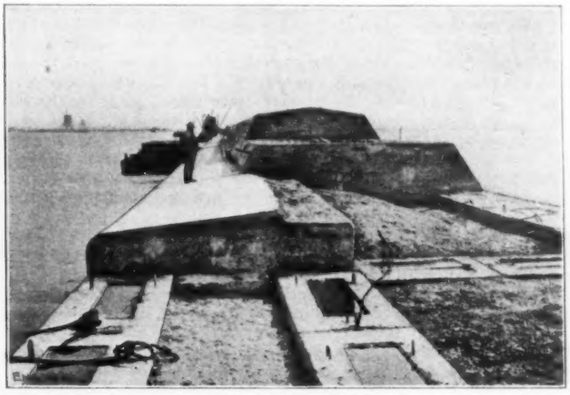


FIG. 10. CONCRETE SUPERSTRUCTURE IN SUCCESSIVE STAGES OF CONSTRUCTION; CONCRETE BLOCKS; BANQUETTE; PARAPET WALLS, AND DECK.

when in use by short iron rods. There are four lines of molds, two on each side of each track. There are altogether 75 molds or forms, 30 for the lake face blocks, 34 for harbor face and interior wall blocks, and 11 for parapet cross-wall blocks. All the molds for the lake face blocks are located on the outside of the railway tracks, to avoid any extra lifting of these, the heaviest blocks.

The mixer was a 4-ft. cube mixer of the ordinary type, supported on the usual timber framework. It was driven by a small upright engine, single cylinder, 7¼ × 8 ins. The steam was supplied from the attached boiler of the double drum hoisting engine used to operate the hoisting derrick. The materials used in the manufacture of the blocks were brought to the dock in canal boats and deck scows. The canal boats were used for the transportation of the broken stone, which came from a limestone quarry located on the south bank of the Erie Canal about one mile west of the town of Lockport, N. Y. The sand and gravel came from the bed of the Niagara River, near the head of Strawberry Island. It was dredged from the river bed by a so-called sand-sucker, transported to the storing yards on the south bank of the Erie Canal, at the foot of Pennsylvania St., Buffalo, N. Y., where it was unloaded by a McMyler derrick operating a clam-shell bucket. It was there reloaded onto scows, of which there were two suitably arranged for the work. The usual load for a scow was 30 cu. yds. of gravel and 60 cu. yds. of sand. These scows were originally dump scows, but the bottom of the pockets was floored over and tightly calked, converting them into deck scows. One scow is 22 ft. wide, 97 ft. long, and 10 ft. sides, the other is 25 × 98 × 9 ft. Each scow contains four pockets, each about 16 ft. square. Auxiliary floors were placed in these pockets a short depth below the combing. One pocket in each scow was covered over with a roof, forming a rude house or shed, which was used for the storage of cement. Each house has a capacity of about 1,000 bags of cement. The cement used was the Lehigh Portland made by the Lehigh Portland Cement Co., of Allentown, Pa. The cement was received both by canal and by rail That received by rail was stored in a warehouse located on the south side of the Erie Canal at the foot of Jersey St. When received by rail it was transferred direct to the scows at the foot of Louisiana St. The method of making the blocks may be described as follows:

The forms or molds were first assembled. The canal boat containing the broken stone was moored alongside the concrete dock, on the side on which the hoisting derrick was located. This broken stone was the run of the crusher (nothing being screened out) containing all the finer particles made by the operation of crushing. The large fragments were usually of a size to pass through a 2-in. ring. The scow containing the sand and gravel was moored on the outside of the canal boat, and the two were moored in such a position that in hoisting concrete ingredients the boom of the hoisting derrick practically remained at a constant angle, this position being controlled by the receiving chute or bin at the top of the mixer. This arrangement avoided the lowering of the boom and the consequent loss of time, a very important consideration from the standpoint of economy and time. The proportion of the materials used in making the concrete blocks was generally as below:

1 part cement, 1 part small gravel and sand mixed, 2 parts sand grit (sand and fine gravel), 4 parts unscreened broken limestone. This was varied according to the amount of sand in the gravel, the grit and the broken stone. The aim was to get a proper amount of sand, ordinary sand and stone-crusher sand, from the three sources to make with the cement sufficient mortar to fill to excess the voids in the larger stone and gravel. No difficulty was experienced in this. The materials were deemed of most excellent quality and uniformity in each load.

The writer knows that the use of unscreened broken stone, run-of-the-crusher, is not in general accord with past engineering practice, but he believes it is the best practice, and that engineers have for years been discarding from their concrete aggregates the best and most valuable parts of the broken stone. The unit of measurement was the bag of cement which was considered as containing 0.9 cu. ft. of cement and weighing from 95 to 100 lbs. The sand and gravel were measured in wheelbarrows, having a capacity of 3.6 cu. ft. The broken stone was measured in a steel bucket to a volume of 14.4 cu. ft. The materials were mixed in batches containing the following quantities each:

4 bags of cement	3.6 cu. ft.
1 wheelbarrow load of small gravel	3.6 " "
2 wheelbarrow loads of sand grit	7.2 " "
Bucket of unscreened broken stone	14.4 " "
Total	28.8 cu. ft.

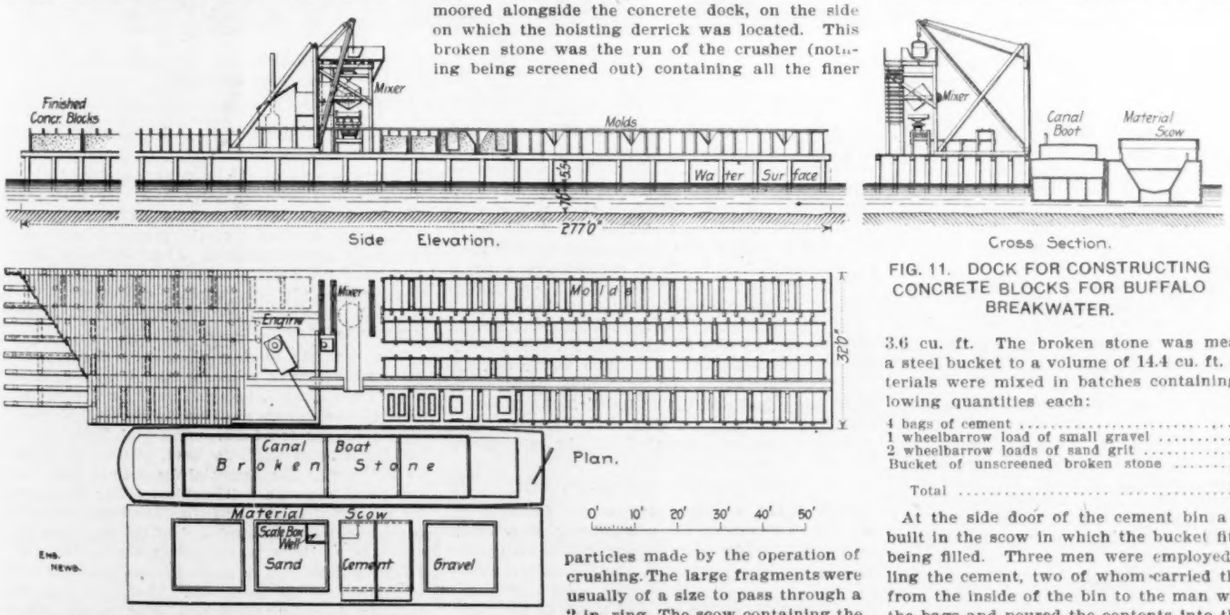


FIG. 11. DOCK FOR CONSTRUCTING CONCRETE BLOCKS FOR BUFFALO BREAKWATER.

At the side door of the cement bin a well was built in the scow in which the bucket fitted while being filled. Three men were employed in handling the cement, two of whom carried the cement from the inside of the bin to the man who opened the bags and poured the contents into the bucket. Two men were employed in loading and wheeling the gravel and dumping the same into the bucket, while three men handled the sand in the same way. After a charge had been placed in the bucket it was hoisted to the top of the mixer and dumped into the receiving chute or bin by tipping the bucket. Two men were employed in looking after the hoisting of the buckets, changing the

ropes from the cement to the stone bucket and vice versa. Seven men were employed in loading the broken stone, which in turn was hoisted to the top of the mixer, the two buckets thus alternating during the entire progress of the work. To operate the derrick, engines and boilers, a force consisting of one engine man, one fireman, and two tag men were required. The engine man attended to the hoisting of the loads, while the tagmen swung the boom which was done by means of tag lines leading through snatch blocks to capstans on the drum shafts of the engine. After a full charge had been placed in the receiving chute, it was allowed to fall through the charging hopper chute into the mixer. Three men were employed at the mixer, one on the top dumping the various ingredients, one regulating the supply of water, and one looking after the hopper chute and putting the mixer in operation. The mixer was given from 15 to 20 turns when the mixed ingredients were dumped into a small car, which was run out on one of the railway tracks to the particular forms being filled. Four men were usually engaged in propelling the car and dumping the mixed materials into the forms or molds. Eight men were employed in tamping and spading the concrete after it was deposited.

The concrete was made quite wet, the water used for each batch ranging between 2 and 2.5 cu. ft. After the concrete was deposited in the forms it was spread out evenly. Especial care was taken to keep the finer material next to the faces. By working an ordinary spade up and down between the concrete and the forms and following this up by tamping with a narrow rammer, a very smooth-faced block was obtained. The block was thus built up in successive layers. The layers after ramming were 0.4 ft. thick in the lake face, harbor face and interior wall blocks, while those of the cross-wall blocks were 0.5 ft. thick. The time interval between batches was usually from 3 to 4 minutes, or at the rate of 15 to 20 batches per hour, equivalent to about 10 to 14 cu. yds. per hour.

From careful records taken at various times of the number of batches entering into the composition of the different kinds of blocks, the following table is deduced. It was found that one batch of materials containing 28.8 cu. ft., measured separately, made 20 cu. ft. of finished concrete, or that it would take 38.88 cu. ft. of materials to make one cubic yard of concrete. Putting this in tabular form, we have:

5.4 bags or 1.35 bbls. of cement	4.86 cu. ft.
Small gravel	4.86 " "
Sand grit	9.72 " "
Unscreened broken stone	19.44 " "
1 cu. yd. of concrete	38.88 cu. ft.

As soon as the concrete had set sufficiently hard, the molds were removed from the blocks, and they were marked with their number, date of making, etc. The time for removing the molds varied considerably, being governed largely by the exigencies of the work, but may be stated as varying between 24 and 72 hours. The blocks, of course, were allowed to set a longer period before handling and placing in the work. To facilitate the handling of the blocks, each was provided with three iron bolts molded in the top face. These bolts had unequal legs, the longer 24 ins. and the shorter 12 ins. long. The longer leg had a square turn at the bottom about 4 ins. long, while the turn of the shorter was about 2 ins. The bolts were driven into the soft concrete on or about the completion of the block, care being taken to consolidate well the concrete around the bolts by thorough ramming.

The blocks were transferred from the dock onto deck scows by means of a large floating derrick, the loaded scows being towed to the work which was located about one mile from the dock. For lifting the blocks, three lifting chains were used, each attached with one end to a common ring and supplied at the other end with a strong hook which engaged in the bolts before mentioned. Two of the lifting chains were provided with turnbuckles for adjusting the proper length of the same, in order to make the blocks hang level. The ring of the swing chains was hung from a loaded hook attached to the blocks of the hoisting cable.

In order to determine the actual weight of the concrete blocks, the displacement of the deck scow transporting these blocks was taken for five different loads, ranging from 88 to 112 tons. From this data the weight of a cubic foot of concrete was determined to be 152 lbs., the concrete being five days old.

Soon after the construction of the banquette deck No. 42, a heavy storm displaced the same. This deck weight was approximately 200 tons, and it was shifted bodily at one end over 2 ft. It had to be blasted out by dynamite. The specific gravity of ten pieces ranging in weight from 8 to 30 lbs. was obtained, from which the weight of the concrete was found to be 151 lbs. per cu. ft. The concrete was about two weeks old. A block containing 1 cu. ft. was also made from the actual mixture and was found to weigh 152½ lbs., a few days after manufacture. Five months thereafter it weighed 151 lbs., showing a loss of 1.5 lbs. or about 1%.

CONCRETE SUPERSTRUCTURE.

Much of the timber superstructure damaged by the gale of Nov. 21, 1900, was entirely swept down to the water's edge. On other portions the timber walls were left standing in various stages of demolition. Many of the interior cross and longitudinal ties were torn out and much of the stone filling washed out. The cribs had originally been sunk to a few tenths of a foot above water level. The different gales had caused a settlement of from 1 to 2 ft., with a probable average of 1.5 ft. These storms coupled with a heavy ice movement also produced a deviation in the alinement. The original line was almost perfect, and the greatest movement from it was 2 ft. towards the h... and 1 ft. towards the lake side, a total var... of 3 ft. between extremes. The settlement ... cribs proved to be an advantage rather ... otherwise, the tops of the same in many ... closely approximating the required grade ... 2 ft. below mean lake level.

After a section of timber superstructure ... been wholly removed to the crib level, the to... the cribs were prepared for the reception o... concrete blocks. Where the cribs were too ... for the established grade, the timbers ... trimmed down. When too low, they were shim... up by planking thoroughly spiked to the u... lying timber. Owing to the deformation of ... lake and harbor faces of the original crib ... structure by the various gales, it was not p... ble to preserve a straight alinement for the ... concrete superstructure. An accurate survey ... the position of the cribs was made, from ... plan of which the lines of the new structure w... determined.

The lake face blocks were set to approxim... these established lines, which necessitated in ... case an overhanging of 1.6 ft. On the h... bor side the blocks were set to follow more clo... ly the faces of the cribs, with the result that ... line of the work is somewhat irregular. T... maximum overhang of the harbor face blocks ... 0.7 ft. These construction conditions caused ...

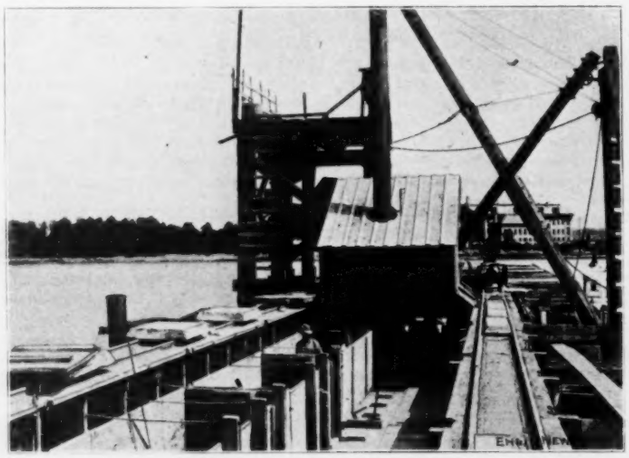


Fig. 12. Concrete Mixer and Molds on Construction Dock.

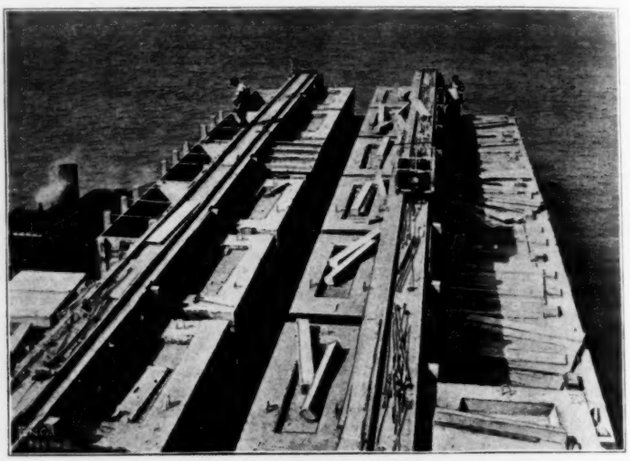


Fig. 13. View Looking Down from Top of Concrete Mixer, Showing Concrete Molds and Completed Concrete Blocks.

VIEWS OF CONSTRUCTION DOCK FOR MAKING CONCRETE BLOCKS.

The concrete blocks were set in place by large floating derricks, expressly built for this work. No fixed procedure was followed in setting the blocks, the condition of the prepared foundation generally governing this. After sufficient blocks necessary for a complete section had been placed, the work of placing the mass concrete was commenced. The banquette sections were invariably constructed first.

The concrete mixing plant is a floating one, an old dismantled schooner, the "Tracy J. Bronson," built in 1857, being utilized for the installation of the mixer, engines, boilers and derricks. The schooner is of 227 gross and 263 net tons burden, and is 137.3 ft. long, 26.6 ft. wide and 11.6 ft. deep. The essential features of this floating plant are—the 5-ft. cubical mixer, supported by the usual trestle or frame work and which is placed near the forward end of the schooner. The mixer is run by a horizontal engine having a 9 × 12-in. cylinder and is located immediately back of the mixer on the port side. There are also two hoisting derricks placed amidships, one on either side, one for handling the concrete ingredients and the other the mixed concrete. The two skeleton hoisting engines used for operating the derricks are also located amidships aft of the derricks. They are double-drum, double-cylinder engines made by the Contractors Plant Manufacturing Co., of Buffalo, N. Y. The cylinders are 7 × 10 ins.

The boiler for supplying steam is located behind the engine. It is a 4 × 10 ft. locomotive boiler. A large force was necessary to operate the plant. It consisted of 3 engine-men, 4 tagmen, one fireman. The same material scows and canal boats were used as for the concrete blocks. In making the mass concrete the mixer boat was moored alongside the breakwater, always with the inboard side towards the same. The canal boat containing the broken stone was moored on the port side of the mixer boat, and the scow containing cement, gravel and sand on the outside of the canal boat (see Fig. 9). The details for handling the concrete ingredients and mixed concrete were similar to those employed on the concrete dock, with the only exception that two derricks instead of one were used, one derrick handling exclusively the cement, sand, gravel and broken stone, and the other the mixed concrete. The mixed concrete after passing through the mixer was deposited in a steel skip or box which rested on a small railway car, and which after being run from under the mixer was swung by the derrick onto the work and back again.

The proportions of the various materials composing the mass concrete were identical with those of the concrete blocks, except that they were mixed in larger quantities, these being exactly one-half greater. The quantities for one batch were as below:

5.4	cu. ft.	of	cement equal to 6 bags, or 1⅛ barrels.
5.4	"	"	gravel equal to 2 small wheelbarrow loads.
10.8	"	"	sand grit equal to 3 large wheelbarrow loads.
21.6	"	"	unscreened broken stone, 1 whole steel bucket.
43.2	"	"	total.

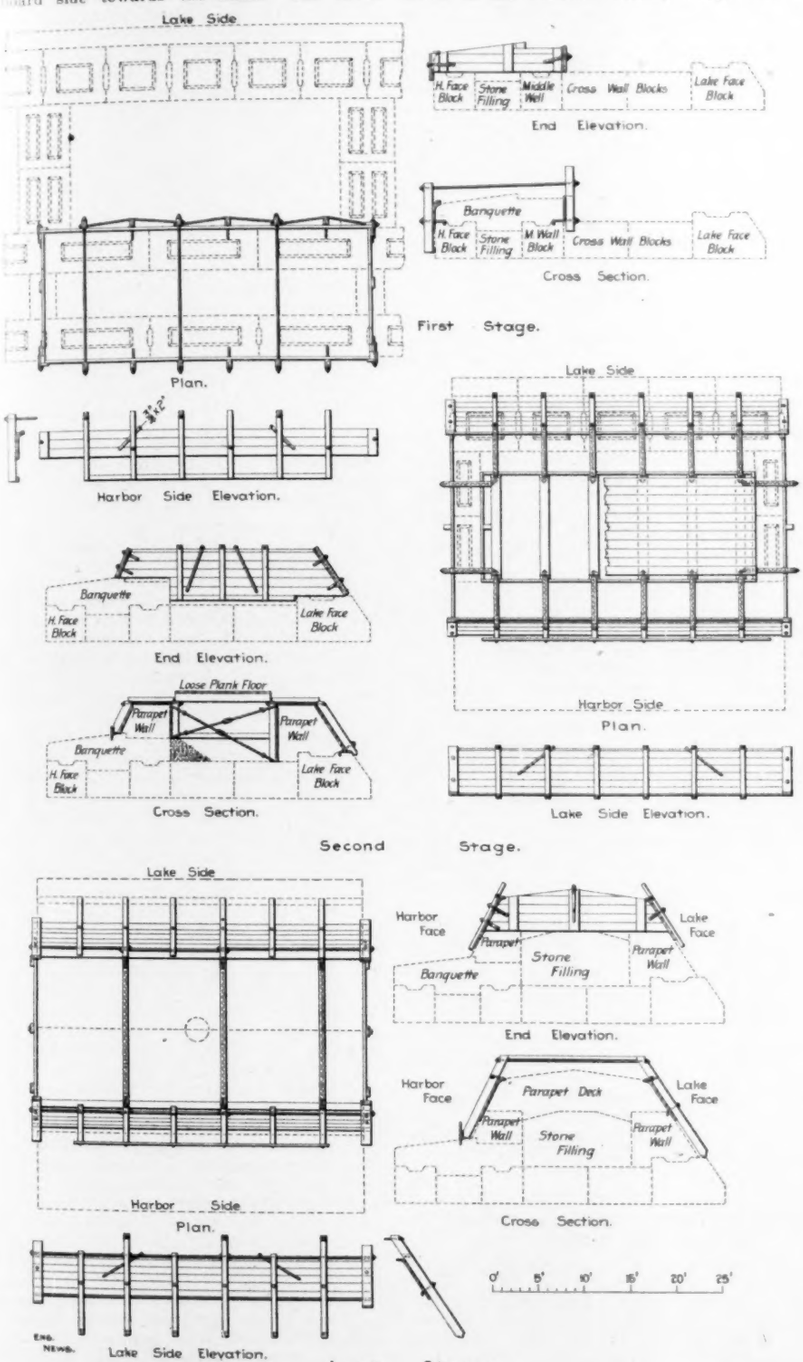


FIG. 14. TIMBER FORMS USED IN CONSTRUCTING MASS CONCRETE PORTION OF CONCRETE SUPERSTRUCTURE.

The amount of water used for each batch of concrete averaged about 3½ cu. ft., making a thoroughly wet quaking mixture. The mixer was revolved 20 to 30 times which occupied from 1½ to 2 minutes. About 15 batches per hour were usually deposited in the banquette and parapet walls, while about 20 batches per hour were placed in the parapet deck, the larger area of the latter allowing quicker dumping. The force of laborers engaged in the different operations of loading, mixing and depositing ranged from 33 to 40.

But one force was engaged in making concrete, they alternating between the concrete blocks and the mass concrete. With few variations all the men were kept always doing the same kind of work, practically the same force being employed the whole season.

Each 36-ft. section of that part of the superstructure built in mass concrete is composed of three component parts, the banquette, the parapet walls and the parapet deck. These were constructed in the order named. Three separate sets of forms or molds were used, one for each part. The forms consisted essentially of wooden walls made of nominally 3-in. planed plank securely fastened to heavy wooden posts, generally made of 6 × 10-in. stuff, except at the ends, where 8 × 12-in. stuff was used. The lower parts of the forms were secured in place by short bolts, passing through the posts and inserted into holes drilled in the concrete blocks or mass concrete as the case might be. These bolts remained in the work and on the withdrawal of the forms were cut off flush with the faces of the completed work.

The upper parts of the forms were held in place by tie rods and braces. The forms were well made, very easily attached and detached, and all parts were provided with iron lifting straps for convenient handling by the floating derricks. Several sets of each kind of forms were made, one or more being always set up so as to be ready for use when needed. During the progress of the work several storms occurred, during which some of the forms were badly damaged, being torn from their fastenings and washed ashore. Such as could be repaired were again made serviceable and new ones made to replace those destroyed. The narrow ledge on the lake side where the mass concrete was set in 9 ins. proved of much value in providing a footing for the forms and also against the washing of the seas behind them.

In constructing the superstructure, individual sections were not completed in the regular sequence of building the banquette, parapet walls and parapet decks, but the practice was to build a large number of banquettes, then a number of parapet walls, followed by parapet decks. However, it occurred that on some few days work was done on three parts, but obviously on three different sections. In instances of this kind work extended late into the night. The tops of the banquettes and parapet were finished off with a mixture consisting of 1 part cement, 2 parts sand and 1 part gravel. This coating was about 0.3 ft. thick and followed immediately after the final depositing of the coarse concrete, and was also thoroughly tamped and kneaded into the latter, so as to bond and interlock the two and prevent any definite line of demarcation between them. A smooth surface was obtained by a proper manipulation and use of wooden straight edges and floats.

A careful record was kept of the batches of concrete placed in the various parts and sections of the superstructure. This was done by means of a counter which was attached to the boom of the derrick handling the mixed concrete. This counter was automatic in its operations and furnished an absolute record of the number of batches deposited. From this record it was found that each batch containing 43.2 cu. ft. of concrete ingredients made about 28.5 cu. ft. of finished concrete, which would show a shrinkage of 34%. This is slightly more than that determined for concrete blocks.

TESTING CEMENT.

As previously stated, Lehigh Portland cement was used exclusively in this work. This cement is made by the Lehigh Portland Cement Co., of

Allentown, Pa., and was received both by canal and rail. The cement was all shipped in bags, the canal boat loads ranging from 3,200 to 3,600 bags, and the car loads uniformly 600 bags. The usual practice was to take 6 samples from each car load, being one for every 100 bags. Rather more samples were taken from the canal boat loads. The average for the season was one sample for every 87 bags. Each sample contained from 4 to 5 lbs. of cement. This was placed in small paper sacks. For the purpose of identification, duplicate tags were used. These were the ordinary commercial tags, stamped with a rubber stamp containing the date, lot number and sample number. One was attached to the sample sack and the other to the bag of cement from which the sample was taken. These latter tags were collected by the inspector when the cement reached the work, proper reference being made in the prescribed reports in which particular part of the work certain lots of cement were used. The samples were delivered to the cement testing room of the U. S. Engineer Office, Buffalo, N. Y., where the required specification tests relative to fineness, soundness, time of setting and tensile strength were made. Usually 12 briquettes were made from each sample, six neat cement and six standard sand briquettes, the latter in the proportion by weight of 1 part cement and 3 parts sand. For making six neat cement briquettes, 30 oz. of cement and approximately 6 fluid oz. of water was used. For making six sand briquettes, the quantities were 7½ oz. cement, 22½ oz. sand and about 2½ fluid oz. water.

In making the briquettes, the materials were mixed upon a glass slab and molded in the usual manner. In addition, the molded briquettes were subjected to a pressure (by means of a weighted lever) of about 64 lbs. or 16 lbs. per sq. in. of surface. The briquettes were kept in air until thoroughly set, then immersed and kept in water until tested. Altogether 954 samples were taken from 84,408 bags, or one from every 87 bags. 613 samples were tested, one for every 136 bags. The total number of briquettes made was 4,417.

Not all the cement tested was used in the South Harbor breakwater, but some was used in the South Pier work, which work was done by the same contractors and at the same time. The following table shows the average results of the cement tests made:

			Lehigh Portland.
Samples tested			613
Fineness, No. 100 sieve			94.1
Time of setting: Initial			0:58
Final			4:36
Tensile strength lbs. per sq. in.	Neat	7 days	687
		28 days	775
		6 mos.	796
	Quartz sand 1:3	7 days	225
		28 days	324
		6 mos.	416

A number of briquettes of cement and stone crusher sand made from limestone mixed in the proportion of 1:3, show the following surprising results:

Tensile strength, pounds per square inch.

24 hours.	7 days.	14 days.	21 days.	28 days.
72	375	396	458	567

This, among other things, shows the value of the stone-crusher sand and dust which engineers have been industriously throwing away for so many years.

The engineers in direct charge of this work have been Messrs. J. C. Quintus and Emile Low, both Members of the American Society of Civil Engineers. The contractors were the Buffalo Dredging Co., of Buffalo. Owing to the great strike of machinists in the spring of 1901 the company was greatly delayed in getting its plant ready for the work. This and various other causes prevented the company from fully completing the work during the season of 1901, but all the cribs were covered and left in a good condition for winter, and the work was finally completed on May 12, 1902.

UNIT PRICES AND COSTS.

The cost of breakwater structures varies greatly. There are so many contingencies and varying conditions entering into their construction that even for structures of approximately uniform design and size, the cost will vary disproportionately. Such disproportionate variation of cost occurs in different parts of the same breakwater, and notably so at Buffalo. The breakwater at Buffalo extends across the end of Lake Erie, and is composed of four sections aggregating over 22,600 ft., or over 4¼ miles in length.

The two sections known as the Old Breakwater and the South Harbor Breakwater are apparently equally exposed to storm and wave action. Nevertheless, such is not the case. The South Harbor section is obliged to withstand a wave force probably twice as great as the apparently equally exposed Old Breakwater. Obviously this implies a heavier structure on South Harbor section, and an increased cost, not only for larger amounts of material entering into it as compared with the Old Breakwater structure, but for largely increased contingencies, notably risk and danger to plant and to unfinished work by storms which greatly augment the cost at South Harbor section and produce a disproportionate variation thereof as compared with apparently similar work on the Old Breakwater.

The following data is given to show the cost of the several concrete superstructures on breakwaters mentioned in this paper. The prices for materials are per unit placed in the work.

DUNKIRK BREAKWATER.—Shell concrete superstructure; cost per linear foot of superstructure, $41.12; concrete blocks, per cubic yard, $6.73; concrete in place, per cubic yard, $6.73; concrete manhole covers, $14 each; filling stone, per cubic yard, $1.19.

OLD BREAKWATER, BUFFALO.—Solid concrete superstructure; section built in 1889, per linear foot of superstructure, $110.19; concrete in place, per cubic yard, $9.19; section built in 1891, per linear foot of superstructure, $108.32; concrete in place, per cubic yard, $8.21.

OLD BREAKWATER, BUFFALO.—Shell concrete superstructure: Per linear foot of superstructure, $65.00; concrete blocks, per cubic yard, $6.64; concrete in place, per cubic yard, $6.64; filling stone, per ton, $0.66; concrete manhole covers, $1.25 each; mooring rings, $30 each.

NORTH BREAKWATER, BUFFALO.—Shell concrete superstructure: Per linear foot of superstructure, 36-foot section, $56.34; concrete blocks, per cubic yard, $7.10; concrete in place, per cubic yard, $5.65; filling stone, per ton, $0.69; concrete manhole covers, $3.00 each; mooring rings, $50 each.

SOUTH HARBOR BREAKWATER.—Shell concrete superstructure: Per linear foot of superstructure, $99.44; concrete blocks, per cubic yard, $10.00; concrete in place, per cubic yard, $9.40; filling stone, per ton, $0.80; concrete manhole covers, $5.00 each; mooring rings, $55 each.

The costs per linear foot of superstructure are exclusive of engineering and office expenses, and also exclusive of removing old timber superstructures and repairing crib foundation in the case of the Old Breakwater concrete superstructure and the South Harbor Breakwater.

The cost of this removal and preparation of foundations on the several structures was as follows:

OLD BREAKWATER.—Solid concrete section, per linear foot of breakwater, $5.42. Shell concrete section, per linear foot of breakwater, $7.26.

SOUTH HARBOR BREAKWATER.—Per linear foot of breakwater, $8.00.

A VISIT TO THE PLANT OF THE EDISON PORTLAND CEMENT CO., AT STEWARTSVILLE, N. J.

At the recent meeting of the American Institute of Mining Engineers, at Philadelphia, a report of which we published last week, a chief feature of interest was the all-day excursion, on May 14, to the Edison Portland cement works, near Phillipsburg, N. J.

The plant is not quite finished, but is expected to be in operation in about a month. It was in the best condition for inspection, for it was possible to visit every corner of it without being choked and blinded by dust.

The first visit was made to the quarries. These are two open cuts, one in cement rock and the other in limestone. The method of quarrying is very simple. Two parallel lines of railway track are laid in the bottom of the cut, on one of which runs a heavy steam shovel, and on the other a train of cars to be loaded. A great mass of rock having been blasted down on the side next to the steam shovel, it is picked [illegible] by the shovel and loaded onto the cars. The capacity of shoveling was shown to the party, who loaded in 15 cars, or about 150 tons of rock, in ten minutes. The average time of swinging up and dumping a shovel load was about [illegible] seconds. The cars are short platform cars, each containing a box-shaped skip made of steel plate open at one end, and with a handle at the other by the use of which was seen when we visited the works.

The cement works are at Stewartsville, 2½ miles from the quarries. They are a departure in the cement industry, and every where exhibit Mr. Edison's genius and boldness in violating established precedents. They are not modeled after any other works, and are built by men without previous experience in cement manufacture, and therefore without any old prejudices.

The general process of cement manufacture is fairly simple. It may be briefly described as follows: Find a big quarry of good cement rock, and another of nearly pure limestone. Crush both kinds of rock separately, analyze samples of each and mix in the correct proportions. Then grind as fine as flour. Roast the mixture at a temperature just short of that of melting fire brick; high enough to cause the mixed material to begin to fuse into a clinker. Cool the clinker and grind it again till as fine as flour, and the cement is made. The whole process can be carried out on a small scale in a chemical laboratory. The actual commercial problem is not how to make good cement, but how to make 10,000 barrels of it a day at the lowest possible cost for labor, fuel and repairs.

This is the problem Mr. Edison has undertaken to solve, and he solves it in his usual way, by spending a vast amount of money in the plant and taking plenty of time to design and build it. The result is a plant covering an area of ground, about half a mile long and quarter of a mile wide, the buildings being laid out as shown in the adjoining cut, which we have redrawn from one included in a brief printed description given to each of the visitors.

When we reached the works at Stewartsville the first thing we encountered was an excellent lunch served in the cement stock house, which as yet has received no cement. We then took a long walk along the outside of a great number of buildings of different shapes and sizes, all sheathed with corrugated iron, to the rock crushing house, shown at the extreme right of the plan.

On the track leading to this house was the train of cars which we had seen loaded with rock at the quarry. Three of these cars were hauled up the inclined plane leading to the top of the stock house, up which plane the party tramped in detachments of about thirty at a time, this being the number who could find standing room in the upper floor of the house. There we saw the operation of crushing by the giant rolls, 5 ft. wide and 5 ft. in diameter, the pair weighing 90 tons, and revolving about 200 revolutions per minute.

One of the skips containing about ten tons of rock was lifted by a chain tackle applied to the hook on one end, and gently slid along a plate above the rolls, and its contents were gradually allowed to fall between them and be crushed. The crushed rock then fell successively between three other pairs of rolls, each of 36 ins. diameter, and when it passed through the last set it was reduced to ½-in. and less in size. The second car contained a rock which would weigh at least five tons, and it passed through the rolls as easily as the smaller pieces which were in the first car.

Climbing down the stairs of the crusher house we saw the immense belts and jack shafts with wooden pulleys, and a 500-HP. vertical cross-compound Corliss engine driving them. An inclined conveyor belt took the crushed rock to a dryer house, which is a tall structure containing vertical drying shafts fitted with inclined cast-iron shelves placed above coal-fired furnaces. The capacity of the driers is 3,000 tons per day. The crushed rock is there dried so that it may be more easily crushed by the fine grinding rolls.

The dried rock is then conveyed by another belt to a long stock house of 10,500 tons capacity.

which is of peculiar construction. It is a great trench dug in the ground, with sides about 45°, covered by a steep pitched roof, and divided into bins by cross walls. A belt runs along near the peak of this roof, with a discharging apparatus mounted on rails above the belt, so arranged that the rock conveyed on the belt may be discharged into any one of the bins. Below the trench there is a tunnel, with openings in its roof, through which the stored rock may be led into feeding rolls which deliver it onto another belt. This conveys the rock to the end of the tunnel and deposits it on an inclined belt, on which it travels from underground up an inclined plane to a weighing and mixing house.

In this house there are two receiving bins of 200 tons capacity each, and two weighing bins of 100 tons each. The dried cement rock and limestone, on being delivered to the stock house, are sampled by automatic machinery, and the samples are analyzed in the laboratory, so that the chemical composition of the stock in each bin is accurately known. The cement rock and the limestone are conveyed separately to the two receiving bins in the weighing house, and definite proportions of each are weighed automatically in the weighing bins, and mixed as they are discharged from these bins onto a belt which takes them to the small stock house of 1,000 tons capacity, which is of the same construction as the large rock stock house. Thence the mixed rock is taken by a belt to the fine grinding house.

This contains at present one set of Mr. Edison's patent fine grinding rolls, the same as he used in his ore concentrating plant at the Ogden mines, and others are to be added, bringing them up to a capacity of 5,000 barrels of cement per day. When the house is increased, as shown by the dotted lines in the plan, and other rolls added, the capacity will be 10,000 barrels per day. The engine for driving these rolls is a vertical compound Corliss, of 750 HP.

From these rolls the ground rock is conveyed by belts to the blower house No. 1, which at present contains 16 bins and fan blowers. These blowers are used to take the place of screens for separating the rock, which has been ground to the required fineness from that which is coarser. The ground rock is fed in a thin stream in front of the outlet of the blower, and the fine stuff is blown away in a box, whose sides are of muslin, so as to retain the dust and let the air pass through, while the coarser stuff falls onto a belt which takes it back to the rolls to be reground.

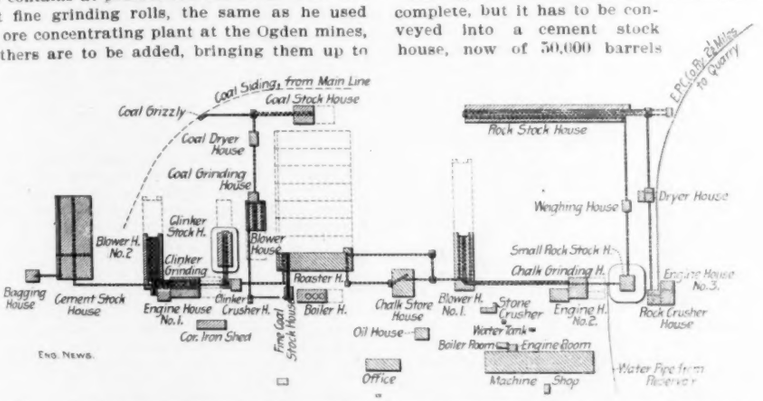
The finely-ground rock, 96% of which will pass through a sieve with 200 meshes per lineal inch, is conveyed from the muslin boxes by a belt provided with scrapers or "flights," which pull it along a trough into the "chalk stock house" of 1,000 tons capacity.

This house has a large floor, on which the ground rock is piled, and a long rotating screw, one end of which is stationary at the exit door of the building and the other is moved in the arc of a circle along the floor, completes the mixing of the rock and delivers it to a conveyor, which takes it to the kiln house. This house contains two large rotary kilns 9 ft. diameter and 150 ft. long, supported on friction rollers. They are made of cast iron and lined with fire-brick. Being set at a slight angle, the ground rock slowly traverses their length, taking about 1½ hours to make the passage. A furnace at the far end of each roaster is supplied with pulverized coal, which is blown in by a strong blast. The temperature at the furnace is expected to reach 3,000° F., which causes the ground rock to be partly vitrified, and become clinker. This falls into a short rotating cylinder, through which a current of air passes, slightly cooling the clinker and heating the air, which then enters the rotary kiln, its heat contributing to increase the temperature of combustion of the fine coal. From the cooling cylinder the still hot clinker falls into a conveying apparatus consisting of a train of steel buckets supported on wheels and propelled by a chain up an inclined plane to the top of the clinker crushing house, in which there are two sets of 36-in. rolls, with a capacity of 3,000 tons per day.

The crushed clinker is then conveyed by a scraper to the clinker stock house, which has a capacity at present of 2,500 tons, but will be increased, as shown by the dotted lines on the plan. Thence it is taken by a belt to the clinker grinding rolls, which are like those in the chalk grinding house. Two sets of these fine rolls are now installed and more are to be added. A 750-HP. vertical cross-compound condensing engine is used for driving them.

The ground clinker is carried to blower house No. 2, which is a duplicate of No. 1, already described, and there the fine dust is separated from that which is not fine enough, which latter is returned to the rolls for regrinding.

The operation of making the cement is now complete, but it has to be conveyed into a cement stock house, now of 50,000 barrels capacity, which is to be increased in size, and thence to the bagging house, where it will be put into bags and shipped. To recapitulate the above description, the cement in the several stages of its manufacture passes through no less than 15 different buildings, as follows:



GENERAL PLAN OF WORKS OF THE EDISON PORTLAND CEMENT CO., STEWARTSVILLE, N. J.

1. Rock crusher house.
2. Dryer house.
3. Rock stock house.
4. Weighing and mixing house.
5. Small rock stock house.
6. Chalk grinding house.
7. Blower house No. 1.
8. Chalk stock house.
9. Roaster house.
10. Clinker crusher house.
11. Clinker stock house.
12. Clinker grinding house.
13. Blower house No. 2.
14. Cement stock house.
15. Cement bagging house.

Besides the houses above named, there are a boiler house, containing at present three 500-HP. Climax boilers, a coal stock house, a coal grinding and blower house, and a fine coal store house. Besides the large engines mentioned above, there are several high-speed engines for furnishing electric current for lighting, and for driving the belt conveyors and blowers and other machinery. There is also a large machine and forge shop, in which most of the machinery and structural work was constructed. There are now 600 men engaged in construction. The whole plant is a model of careful design and fine workmanship.

The plant in its entirety was designed under the personal supervision of Mr. Edison, and all the machinery used is of his own invention.

A model on the scale of 2 ins. to the foot was set up at the Edison Laboratory at Orange, and the various units of machinery to be used in the mill were given service tests at the laboratory.

The plans for the mill were made under the supervision of Mr. Edison's chief draftsman, Mr. Wm. Simpkin. The mill, with its quarries and railroad, has been constructed under the supervision of the company's engineer, Mr. Edward A. Darling.

The officers of the company, whose general office is in Philadelphia, are as follows: Wm. H. Shelmerdine, President; Mr. W. S. Mallory, Vice-President; Mr. W. S. Pilling, Treasurer; Mr. T. I. Crane, Secretary; and Mr. Thos. A. Edison, General Manager.

CREOSOTING WOODEN POLES FOR ELECTRIC LINE WORK.*

By W. E. Moore.†

In the operating expense of most companies approximately one-third of the income goes toward the distributing expense, of which the maintenance of lines constitutes quite a large item. The principal cause of the depreciation in the lines is due to the decay of poles, for as yet but few lighting companies have begun the use of iron or creosoted poles, though iron poles are extensively used for street railway purposes.

The wooden pole is usually of cedar, heart-sawed pine, cypress, juniper or redwood, and is generally used on account of its low cost and the comparative safety with which workmen may handle the live wires when standing on the cross-arms, as wood is a fair insulator.

Red-cedar and white-cedar poles, while they have a comparatively long life, have now become so scarce that it is extremely difficult to secure them in sufficient numbers of suitable sizes for electric light lines at any price in the Eastern or Southern market, though there is yet a considerable supply of white cedar to be found in the Northwest.‡ Cedar, when of good quality, has the capacity of resisting the attacks of insects and fungus growths to a greater extent than any other wood used in this country for poles. This statement applies only to the heart of the stick, and more especially to red cedar; the sap or white portion quickly rots away at a point near the ground. In the Southern and Eastern States cypress is largely used, and in its natural state has a life of from five or six years in the southern portion of the United States, and a somewhat longer life in the North.

Heart-sawed pine poles have a somewhat longer life than cypress, ranging from eight to nine years; but sap pine, though readily secured in sticks of suitable size and of the necessary length, is never used, on account of its rapid decay. It lasts scarcely more than three years when used without being treated with some preservative compound. It is much more expensive to renew decayed poles than the original cost of setting them, due to the fact that they do not all decay at one time and it is therefore necessary to set them piecemeal; and it is also necessary to take care of the wires while they are being reset, which is often quite expensive in case there are a large number of wires attached to one pole, especially junction poles.

For this reason the Augusta Railway & Electric Co. began, some nine years ago, to study the problem of treating poles by some preservative compound to increase their life. Our first experiment consisted of charring the butts of the poles, up to and about 1 ft. above the earth line, and then saturating them with a coal-tar paint; but this was found to be of little service. We then tried painting the poles with various brands of preservative compounds sold under different trade names. These also were found to be of little or no benefit. In the meantime our poles, which were almost entirely of cypress, continued to rot out after an average life of about five or six years.

Some three years ago, after having investigated the results obtained both in this country and abroad from creosoting poles, we purchased and installed a creosoting plant capable of treating both poles and cross-ties. This plant consists of a steel cylinder 6 ft. diameter and 102 ft. long, with heavy cast-iron heads, securely supported on hinges and arranged to be clamped against a fibrous gasket on the head of a cylinder so as to resist a hydrostatic pressure of 150 lbs. This cylinder has a narrow gauge railway laid through it, with tracks continuing beyond the ends of cylinder; there is sufficient ground room at one end for untreated poles, and at the other for treated poles. The cylinder has a series of 1-in. pipes laid from end to end and covering the bottom. These are supplied with steam from an 80 H.P. return

*Abstract of a paper read at the annual convention of the National Electric Light Association, at Cincinnati, O., May 20.

†Augusta Railway & Electric Co., Augusta, Ga.

‡The same is true of poles for electric railways, as noted in a recent article in the construction of the Grand Rapids, Holland & Lake Michigan Electric Ry.—Ed.

tubular boiler, the steam being superheated (by means of pipe coils in a separate furnace) to a temperature of approximately 400° to 500°. To the cylinder is also connected a direct acting vacuum pump, 14 × 24 ins., and, again, a direct acting oil-pressure pump, 10 × 18 ins.

The poles are loaded on to a train of iron cars which are then drawn into the cylinder by means of a wire rope attached to a hoisting engine. The cylinder doors are bolted up tight, after which live steam is turned on the cylinder until a pressure of 80 lbs. is reached, which is maintained while superheated steam is being circulated through the heating coils in the bottom of the cylinder. This steaming process is continued for a period of from four to six hours, depending upon the size of timber that is being treated. The steam pressure is then drawn down and a vacuum created in the cylinder, the timber having been heated up to about 350°. The vacuum is maintained for six to four hours, drawing the sap and air from the green timber. This is facilitated by the steaming to which the timber has been subjected, which has had the effect of dissolving the sap and raising it to a temperature far above the boiling point, due to reduced pressure when the vacuum is applied. The sap in the pores of the wood is immediately volatilized upon the application of vacuum, which has the effect of making the extraction of both sap and air very rapid and complete. During this time a quantity of sap is pumped from the cylinder through the vacuum pump. The valve connecting the oil storage tanks (which are of 30,000 gallons capacity and located in a pit below the cylinder) is then opened and the atmospheric pressure forces the creosote oil up into the cylinder until it is filled. After this the oil pressure pump is started, drawing its supply from a tank which has a gage attached, calibrated to gallons. After the pump has completely filled the cylinder, its operation is continued until the required number of gallons of oil have been pumped into the cylinder to saturate the timber (the cubic contents of which have previously been figured) to a density of 10 to 12 lbs. per cu. ft. This ordinarily requires a pressure of 60 lbs. per sq. in., applied for a period of time ranging from two to four hours, depending upon the diameter and kind of timber being treated. After the required number of pounds of oil have been injected into the timber, the oil is drawn from the cylinder into the storage tanks, and the steam is left circulating through the superheating coils for about one hour, which is done for the purpose of somewhat decreasing the oil drippings from the timber, which would otherwise take place.

It must be understood that steam is circulated through the superheating coils located in the bottom of the cylinder throughout the entire process, which ranges from 16 to 24 hours. The doors of the cylinder are then opened and the cars with their load of treated timber are drawn through the cylinder to the unloading yard by means of the hoisting engine applied through a wire cable. Another train of cars, which is standing already loaded at the other end of the cylinder, is immediately drawn in and the process repeated.

The approximate cost of the average size (say 34 ft. long, 8 in. top diameter) of cypress pole in the South ranges from $1.75 to $2.00 each, and the cost of creosoting approximates $20 per 1,000 ft B.M., or about twice the first cost of pole. While we have no time test showing the ultimate life of creosoted poles in actual service, we have every reason to believe that their life will be prolonged four to six times that of untreated timber.

The Bell Telephone Co. has used creosoted pine poles for upwards of ten years, and where the treating has been properly done they have yet to show the first signs of decay. Sir William Preece, of the British Telegraph Department, reported that creosoted poles had been in use in England for more than 30 years without showing indications of decay. Since the cost of treating a pole averages about twice its first cost, the economy of creosoted poles must be apparent.

Thus far we have found only one objection to creosoted poles, which is due to the tar acids contained in the creosote oil, principally carbolic acid. The effect of this acid is to make the handling of the poles disagreeable, as it inflames the hands of those who handle them, and at the same time it lowers the electrical resistivity of the timber to such an extent that linemen can no longer depend upon the poles to insulate them from the ground when handling wires carrying 1,000 to 3,000 volts.

ANNUAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

A brief announcement of the annual meeting of the American Institute of Electrical Engineers (held on May 20, at New York), was given in the supplement to our issue of May 22. On account of lack of space, however, the note gave only a title reference to the papers read at the meeting. As these papers and the brisk discussion which followed them were of much interest, we outline in the following the main course of the argument.

SOME NOTES ON EUROPEAN PRACTICE IN ELECTRIC TRACTION WITH THREE-PHASE ALTERNATING CURRENT.—C. L. DE MURALT.

The author, himself a European engineer, and connected with some of the work he talked about, gave brief, summarized descriptions, in chronological order, of the different experimental and other alternating current tramway lines in Europe. These lines are nearly all of them in Switzerland and have heavy grades and sharp curves, several of them being fitted over all, or a portion of the line, for rack operation. The lines described in the paper are: (1) The Charlottenburg, Germany, test line of Siemens & Halske, 1892, exhibited at the Chicago Exposition in 1893; (2) the tramway system of Lugano, Switzerland, three miles long, installed by Brown, Boveri & Co., in 1895; (3) the Gornergrat railway, Switzerland, 5.6 miles long, built in 1897 by Brown, Boveri & Co.; (4) the Jungfrau railway, Switzerland, 8 miles long, 1898, Brown, Boveri & Co.; (5) the Stansstad-Engelberg railway, Switzerland, 14 miles long, opened in 1899, Brown, Boveri & Co.; (6) the Burgdorf-Thun railway, Switzerland, 25 miles long, 1899, Brown, Boveri & Co.; (7) the Lecco-Colico-Sondrio railway, in Northern Italy, 65 miles total length, 1901, Ganz & Co.; (8) the experimental line of Siemens & Halske, at Grosslichterfelde, near Berlin, Germany, 1899 and 1900, and (9) the Zossen, Germany, experimental line of the Society for the Study of High-speed Electric Traction. Of these the Gornergrat and Jungfrau railways are mountain lines, with grades up to 25%, and are rack operated; the Stansstad-Engelberg line is partly with rack, the remainder adhesion. The Burgdorf-Thun line operates very nearly under steam railway conditions, and is a connecting link between a number of the main line railways of Switzerlad. The Lecco line is normal gage, and carries both freight and passenger traffic.

The author gave, for each case, data as to grades, speeds, loads, traffic, power supply, car and line equipment, etc. Following this he detailed some experiments made by him on the Burgdorf-Thun line, in which he measured speed, voltage and current. Finally, the author presented some general conclusions drawn from the experience of the lines described, and from his experiments, these conclusions being rather favorable to alternating current as compared with direct current, and somewhat optimistic as to the possibilities of electric traction on main line railways.

Before the discussion of this paper was taken up, President Steinmetz briefly abstracted the contents of the second paper, the author being absent.

A NOVEL COMBINATION OF POLYPHASE MOTORS FOR TRACTION PURPOSES.—E. DANIELSON.

The main difficulty in applying alternating current to traction work appears to be the inflexibility of the induction motor as to speed, and the only slight variation in torque obtainable. The most fruitful suggestion in this line has been Steinmetz' concatenation method, in which the secondary of the first induction motor connected with the primary of the second gives a speed of half the synchronous speed. Thus, by employing two equal motors, two speeds can be obtained, one the synchronous, the other half that speed. The author goes on to show that unequal motors of a different number of poles and, hence, different speeds, may be combined in this same way, and that by this arrangement three speeds are secured. Further, if these motors be connected in "differential concatenation," the second motor acting against the first, we get a fourth speed. The same result is reached by using two equal motors with different gearing. The paper enlarged somewhat on the possibilities of this combination of induction motors.

DISCUSSION.

Mr. C. O. Mailloux, referring to the first paper, stated that he was familiar, by personal inspection, with all the lines mentioned, and had been particularly impressed with the Stansstad-Engelberg and the Burgdorf-Thun lines as operating under conditions close to those of steam railroads. What had struck him, however, in their operation was the low acceleration used, which may also be deduced from figures in the paper of Mr. de Muralt. As viewed in this country accelerations of ¾ to 1 mile per hour per second were hardly accelerations at all, practice calling for accelerations of 2, 2½ and even 3 miles per hour per second. He emphasized that acceleration was the vital point in electric traction work, and that it was the crucial point in most cases in this country where direct and alternating current might compete in traction work. With alternating current induction motors, sufficient acceleration is, if not impossible, to obtain, at least too difficult and too expensive. The speaker thought, however, that when electric railroading should approximate steam railroad conditions, then we would have to look to alternating current; but even then, to make such working practicable, we would either have to combine the advantageous qualities of the direct-current series system with the alternating-current working, or the latter would have to be perfected much beyond the point it has reached to date. In this connection he was much interested by Mr. Danielson's paper, which he thought suggested one line along which such advance might take place.

Mr. H. G. Stott pointed out that 10,000-volt trolley lines might be a source of danger in case of [illegible] trolley contact starting a bad arc, which might [illegible] the other trolley wires, especially if these were [illegible] above each other. He was also struck by the [illegible] quency of substations on the Swiss lines mentioned by Mr. de Muralt, where transformer stations were often only 2 to 3 km. apart. Contrasted with in rotary converter substations this would represent considerable extra investment.

President Steinmetz drew attention to the [illegible] motive-power units employed in the lines mentioned. The car units of less than 200 H.P. were surpassed in this country in much of the ordinary city traction work, while suburban work generally much exceeded these figures. In this connection, and also referring to the statement in the paper as to maximum current per motor, he mentioned a suburban line in this country, where cars equipped with 250 H.P. of motors, on which he had seen a car climbing a steep grade take as much as 800 amperes from one trolley. The car had two motors, but in actual running it was impracticable to use more than one. He further pointed out the great disadvantage produced by the inflexibility as to speed and torque, of the alternating-current system, in matters like maintaining schedules, making up lost time, rescuing a disabled car on a steep grade; all these are serious considerations in practical traction work, and must be met by any system claiming favor. As another point the advantage of returning power to the line in coasting is rather shadowy, since when the normal speed is at all high even to return current to the line by coasting above synchronous speed would generally mean running at a speed which could not be permitted for safety.

Some further discussion took place on matters like wear of bow-trolleys, wear of trolley wires, permissible drop in voltage on alternating current trolley systems, use of rail for third conductor and its effect on the balance of the phases, etc.

A short discussion between Mr. Mailloux and Mr. de Murait referred to acceleration. The latter claimed that high acceleration could be provided if it was called for, with alternating current motors equally as well as with direct. Mr. Mailloux was of the opinion that the alternating-current motor had a narrow limit of excess of starting torque, and that this could not well be increased. However, if a variable-speed device were employed then the matter of starting torque of the motor would be of little importance. President Steinmetz brought out that the matter of starting torque depended upon what the capacity of the motors was proportioned for. If, as is usual, it is made equal to the average running power, then with direct-current motors we can get enough excess torque at starting to even slip the wheels, while with the other the starting torque can reach at best a value three to four times the running torque. The alternating-current motors might be made much larger, but then they would be only partially loaded when running, with all the effects on efficiency and power factor that this would involve.

In closing, Mr. de Muralt took occasion to answer some questions and reply to statements made in the discussion. On the Burgdorf-Thun line the acceleration was low because no higher had been asked for; he thought that if necessary, alternating-current motors could give an acceleration up to 1½ miles per hour per second. On these lines no trouble had yet arisen from imperfect contact at the trolley or sparking. The drop in voltage is usually limited to 6 to 10 %, but sometimes ran up to 15 %. The use of the rail as third conductor has caused no trouble in unbalancing the circuit, probably by reason of the high frequencies used; these latter were originally determined by the fact that the system had to supply lighting current also. The durability of the bow trolleys has been found satisfactory; they last usually a whole summer season, but require changing oftener in the winter. The bows are of softer metal than the trolley wire, so that little wear of the latter is noticed. On the subject of maintaining schedule or making up time, he thought that the alternating-current system was not much at a disadvantage, and stated that no particular trouble had arisen from this fact on the European lines under discussion.

DIVERGENCE OF LONG PLUMB LINES IN THE TAMARACK SHAFT.

From an article written by Prof. F. W. McNair, for the "Electrical World," some notes are here made on a subject that has puzzled other engineers; and that is, the observed divergence of long plumb lines.

In this case the lines as hung were 4,250 ft. long; they were No. 24 piano wire, with 50-lb. cast-iron bobs swung in pails of cylinder oil; they were protected at the bottom from dropping water. After the wires had settled as much as they would, a check measurement was made of the distance between the wires, at top and at bottom of shaft. The upper measurement was 16.32 ft., the lower 16.43 ft., showing a divergence of 0.11 ft. The

shaft was carefully explored for obstructions; and the western wire was then moved westward 1.26 ft. When all was quiet again, measurement showed, 17.58 ft. at the surface, 17.65 ft. below, or a divergence of 0.07 ft. It was at first supposed that the 16-in. and 4-in. air-pipes in the shaft were acting as magnets upon the west wire and attracting the bob out of position; especially as the east bob was little affected. Lead bobs were then used, with the wires in plumbing another shaft, 120 ft. shorter than the first; there was again a divergence of 0.10 ft.

Prof. McNair then gives further experiments in detail and also discusses the many theories presented to explain this divergence. He finally concludes that the air currents in the shaft were alone responsible, as the result of experiments in which the top of the shaft was closed and a number of the openings at the different levels shut up. He found that the circulation could not be wholly stopped, owing to the differences in temperature between top and bottom, but the trials convinced the experimenters that the air-current accounted for all the difference found. The constancy of the observed divergence was accounted for by the great depth of the shafts, and the constancy of temperatures influencing the currents for long periods of time.

TREATMENT OF SEWAGE IN A LARGE OPEN SEPTIC TANK AT WORCESTER, MASS.

In May, 1900, Mr. Harrison P. Eddy, Superintendent of Sewers of Worcester, Mass., began to treat a portion of the sewage of that city by the septic process, utilizing one of the chemical precipitation tanks for the purpose. The following information regarding the experience with the tank is taken from Mr. Eddy's report for the year ending Nov. 30, 1901:

The tank has a cubical capacity of 350,000 gallons, or a net capacity, after allowing for sludge deposits, of, say, 300,000 gallons. Up to September, 1901, the rate of flow through the tank was 300,000 gallons a day, and from then to December, 1901, 500,000 gallons, giving 24 and 14 hours detention for the respective periods. The removal of organic matter did not seem to be materially effected by the increased rate of flow.

On June 28, 1901, or over a year after the septic tank was put in operation, about 80,000 gallons of thin, finely divided sludge was removed from the tank. After six tons of lime had been added to the sludge filter pressing was begun. So much difficulty was encountered in forcing the sludge through the press that, to save time and expense, part of it was discharged onto the sludge liquor filter beds.

The scum on the septic tank has not exceeded 4 ins. in thickness and sometimes wind and rain has caused its entire disappearance.

The tank gives off disagreeable odors, but not so bad as those from the larger exposed area of the intermittent filters which receive the tank effluent. The odor from the filter beds continues after the applied liquid has disappeared, owing to the moisture on and near their surface. This odor, Mr. Eddy believes, will prove to be the most serious objection to septic tanks wherever there are dwellings or highways near the filter beds.

The monthly operations of the septic tank from July, 1900, to November, 1901, inclusive, are shown by the accompanying table. It will be seen that for the last full year covered by the analyses the total albuminoid ammonia was reduced 31.45%, while the removal by months ranged from 0.71% for August, 1900, to 46.30% in July, 1901. Other analytical results are given in detail and may be examined by those interested.

The report also contains a table showing the effect of intermittent filtration on the septic effluent. This table is not reproduced here. Mr. Eddy states that the effluent from these filter beds has been about the same as that from beds receiving ordinary sewage, but the rate of filtration has been materially higher.

The finely divided suspended matter in the septic effluent forms a coating on the surface of the filters as impervious to air and water as the coating from crude sewage, but apparently of less volume.

It should be remembered that the Worcester sewage contains iron and acids from the manufacturing wastes of the city, as set forth in some detail in the abstract of Professor Kinnicutt's and Mr. Eddy's account of the small closed experimental septic tank at Worcester, published elsewhere in this issue. Storm water was excluded from the large septic tank discussed in the present article. Possibly some deposits of organic matter occur in the 300 to 400 ft. of 13-in. pipe which supplies sewage to the large tank.

In conclusion, Mr. Eddy says of the septic tank:

While this municipal cesspool might be adopted in some places, it would appear to be wise to so design the plant that it could be readily adapted to the method of chemical precipitation.

RESULTS OBTAINED WITH THE LARGE OPEN SEPTIC TANK AT WORCESTER, MASS., JULY, 1900 TO NOVEMBER, 1901.
(Parts per 100,000.)

	Residue on evaporation. Total.	Residue on evaporation. Volatile—Total.	Residue on evaporation. Volatile—Sus-pended.	Residue on evaporation. Volatile—Solu-tion.	Residue on evaporation. Fixed.—Total.	Residue on evaporation. Fixed.—Sus-pended.	Residue on evaporation. Fixed.—Solu-tion.	Albuminoid Ammonia. Free.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Solu-tion.	Albuminoid Ammonia. Sus-pended.	Albuminoid Ammonia. Resid-ual.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen consumed. Unfil-tered.	Oxygen consumed. Fil-tered.	Chlo-rine.	Lbs. per million gals. Total iron as sul-phuric acid.	Lbs. per million gals. Free sul-phuric acid.	Flow. Total through tank.	Flow. Aver-age pr day.	Number of bac-teria per 1 cu.cm.	Average temperature. deg. F. Maxi-mum	Average temperature. deg. F. Mini-mum
									July to November, 1900.															
Sewage, July, 1900	71.8	44.6	26.7	44.2	34.5	9.7	10.1	17.0	1.270	.504	.208	1.360	.632	.0014	6.97	4.15	7.06	3.473	172	7,800,000	251,613	.....	....	....
Effluent	44.6	38.2	11.8	32.8	6.4	1.8	14.7	3.6	2.050	.400	.245	1.125	.0022	.0004	6.01	3.21	8.30	3.867	82	Closed Sundays.		.....	....	....
Per cent. removed	37.88	14.35	55.06	25.79	81.45	81.44	85.54	78.82	61.42	20.63	8.58	17.28	31.25	71.43	13.77	22.65	17.63	11.34	52.33	8,100,000	261,290	9,581,200	....	....
Sewage, August	47.0	49.1	44.1	16.4	30.6	21.4	32.4	1.075	.424	.178	.246	1.225	.044	.0109	6.47	4.64	7.23	3.140	131	Closed Sundays.		2,293,700	....	....
Effluent	44.6	20.0	13.9	25.0	30.7	8.0	58.41	1.804	.421	.143	.278	.919	.042	.0065	6.32	3.90	7.65	4.276	146	Closed Sundays.		.....	....	....
Per cent. removed	5.11	59.21	47.83	15.24	0.36	58.41	76.19	67.81	19.06	71.77	213	24.90	4.33	97.0405	2.32	15.67	6.88	4.438	15.27	7,800,000	200,000	7,185,000	47.5	39.4
Sewage, September	46.8	38.2	44.5	16.7	30.1	6.6	27.9	1.363	.717	.213	.504	1.706	.033	.0092	5.90	3.44	6.78	4.411	666	Closed Sundays.		1,508,800	47.4	42.4
Effluent	39.6	14.0	11.7	2.3	25.6	1.4	13.38	1.769	.429	.169	.241	1.498	.022	.0004	6.01	3.21	8.30	3.867	689	—3.47	0.61	.....	....	....
Per cent. removed	15.38	61.33	57.08	29.94	13.38	78.87	51.52	29.76	40.19	20.66	53.52	12.16	33.33	95.65	1.86	6.54	22.46	12.32	47.44	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, October	50.1	28.9	43.2	20.5	21.2	6.2	30.69	1.485	.394	.132	.262	1.091	.028	.0026	6.25	4.27	6.75	3.651	941	1,018	—8.18	1,200,000	50.1	46.3
Effluent	42.6	12.9	12.5	0.4	29.7	3.04	44.23	1.806	.426	.146	.280	1.380	.033	.0016	6.38	3.90	6.86	4.115	200	7,800,000	200,000	1,518,300	73.8	69.6
Per cent. removed	29.75	55.36	71.05	30.62	11.4	51.05	33.3	1.440	.610	.435	.175	1.188	.050	.0026	6.15	4.40	....	....	1,106	Closed Sundays.		2,443,500	....	....
Sewage	71.4	46.1	26.3	32.6	25.3	9.9	19.41	1.993	.435	.143	.292	1.158	.050	.0026	6.18	4.40	....	....	998	14.41		.....	....	....
Effluent	44.9	35.9	7.24	28.69	33.49	71.05	40.21	28.69	33.49	26.08	76.14	60.00	15.36	....	16.71	23.34	....	....	....	....		.....	....	....
Per cent. removed	0.44	65.78	44.95	30.99	61.74	71.05	40.21	28.69	33.49	26.08	76.14	60.00	15.36	....	16.71	23.34	....	....	....	....		.....	....	....
									December, 1900, to November, 1901.															
Sewage, December	57.76	45.82	11.94	20.92	13.19	1.73	36.84	32.63	4.21	1.575	.506	.189	.219	1.425	.143	.0189	6.24	4.89	5.15	4.235	227	.....	....	....
Effluent	35.99	16.92	8.67	17.99	12.24	3.45	34.08	30.64	3.44	1.343	.335	.189	.219	1.415	.058	.0093	5.29	3.45	5.28	3.919	371	1.46	.....	....
Per cent. removed	3.75	2.40	27.39	14.07	7.20	24.13	2.46	6.94	18.41	14.78	33.79	33.86	0.00	0.00	0.84	0.53	15.92	21.27	43.44	4.115	329	35.95	37.2	43.0
Sewage, January, 1901	90.1	56.7	33.4	39.3	35.0	4.3	30.7	3.040	.634	.418	.216	2.580	.032	.0010	6.37	6.57	6.86	4.115	200	20.95		1,200,000	47.9	43.0
Effluent	58.6	48.5	10.76	37.74	10.14	5.62	53.05	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	34.90	14.46	67.76	4.71	29.03	24.71	72.73	17.63	32.81	57.47	16.67	19.46	31.25	66.25	1.73	29.42	15.89	8.57	34.35	8,100,000	261,290	9,581,200	47.9	43.0
Sewage, February	101.8	48.7	17.0	31.8	31.1	10.7	12.33	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	39.95	9.04	68.05	33.44	22.99	12.33	45.77	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	60.6	81.4	60.0	26.0	26.0	0.0	73.9	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, March	45.4	23.2	10.8	12.4	22.2	9.9	20.4	1.240	.429	.156	.273	1.811	.028	.0026	6.25	4.27	6.75	3.651	941	1,018	—8.18	1,200,000	50.1	46.3
Effluent	38.2	21.5	19.6	18.4	16.7	11.2	45.3	1.806	.426	.146	.280	1.380	.033	.0016	6.38	3.90	6.86	4.115	200	7,800,000	200,000	1,518,300	73.8	69.6
Per cent. removed	15.86	7.33	45.3	32.72	24.40	11.2	45.0	1.440	.610	.435	.175	1.188	.050	.0026	6.15	4.40	....	....	1,106	Closed Sundays.		2,443,500	....	....
Sewage, April	47.1	43.0	17.3	25.7	19.1	4.3	28.0	1.993	.435	.143	.292	1.158	.050	.0026	6.18	4.40	....	....	998	14.41		.....	....	....
Effluent	60.3	43.0	17.3	25.7	17.3	12.3	39.7	1.769	.429	.156	.273	1.340	.028	.0026	6.25	4.27	6.75	3.651	941	1,018	—8.18	1,200,000	50.1	46.3
Per cent. removed	8.71	62.32	53.37	38.09	16.12	5.04	29.14	11.23	1.38	2.10	6.85	11.23	44.00	0.00	0.00	0.00	0.00	0.00	5.83	8,100,000	261,290	9,581,200	47.9	43.0
Sewage, May	63.8	42.5	21.3	20.4	10.7	10.1	14.33	1.785	.351	.126	.225	1.750	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	34.1	14.4	10.7	3.7	19.7	3.0	21.22	1.656	.306	.111	.195	1.350	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	18.35	22.59	33.5	25.0	38.3	7.0	20.0	11.02	2.0	1.6	13.3	22.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, June	58.2	31.6	17.6	14.0	26.6	18.4	29.1	2.044	.576	.200	.376	1.822	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	39.42	30.45	15.09	28.09	9.36	2.41	21.65	1.188	.418	.189	.229	.770	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	71.82	23.8	54.2	29.6	64.8	87.1	25.7	41.9	27.4	5.5	39.1	57.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, July	68.5	56.5	14.3	26.3	14.2	12.1	14.33	1.625	.306	.111	.195	1.319	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	21.31	38.60	12.54	26.06	51.47	50.82	36.78	1.194	.306	.111	.195	.888	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	68.9	31.7	12.54	26.0	51.47	50.82	36.78	1.194	.306	.111	.195	.888	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Sewage, August	100.1	68.2	31.9	36.3	26.0	5.7	44.23	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Effluent	67.5	51.4	16.1	27.7	14.3	11.53	45.64	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	32.57	24.63	57.53	23.76	45.0	0.0	3.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, September	100.2	69.6	30.6	35.4	30.6	23.4	39.4	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	49.0	23.4	25.4	18.0	25.6	16.2	21.15	1.656	.306	.111	.195	1.350	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	24.7	24.7	29.0	23.53	16.3	30.7	46.5	43.5	57.5	52.2	60.1	38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, October	91.5	58.7	32.8	39.6	32.8	16.4	40.2	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	50.75	35.75	14.97	20.78	14.97	12.03	16.83	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	44.5	39.0	54.3	47.5	54.3	26.6	58.1	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, November	85.3	58.4	26.9	31.5	28.4	14.5	42.9	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	49.5	28.4	21.1	7.3	21.2	14.2	28.5	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	42.0	51.3	21.5	76.8	25.7	2.1	33.6	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, December	57.76	45.82	11.94	20.92	13.19	1.73	36.84	32.63	4.21	1.575	.506	.189	.219	1.425	.143	.0189	6.24	4.89	5.15	4.235	227	.....	....	....
Effluent	35.99	16.92	8.67	17.99	12.24	3.45	34.08	30.64	3.44	1.343	.335	.189	.219	1.415	.058	.0093	5.29	3.45	5.28	3.919	371	1.46	.....	....
Per cent. removed	3.75	2.40	27.39	14.07	7.20	24.13	2.46	6.94	18.41	14.78	33.79	33.86	0.00	0.00	0.84	0.53	15.92	21.27	43.44	4.115	329	35.95	37.2	43.0
Sewage, January, 1901	90.1	56.7	33.4	39.3	35.0	4.3	30.7	3.040	.634	.418	.216	2.580	.032	.0010	6.37	6.57	6.86	4.115	200	20.95		1,200,000	47.9	43.0
Effluent	58.6	48.5	10.76	37.74	10.14	5.62	53.05	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	34.90	14.46	67.76	4.71	29.03	24.71	72.73	17.63	32.81	57.47	16.67	19.46	31.25	66.25	1.73	29.42	15.89	8.57	34.35	8,100,000	261,290	9,581,200	47.9	43.0
Sewage, February	101.8	48.7	17.0	31.8	31.1	10.7	12.33	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	39.95	9.04	68.05	33.44	22.99	12.33	45.77	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	60.6	81.4	60.0	26.0	26.0	0.0	73.9	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, March	45.4	23.2	10.8	12.4	22.2	9.9	20.4	1.240	.429	.156	.273	1.811	.028	.0026	6.25	4.27	6.75	3.651	941	1,018	—8.18	1,200,000	50.1	46.3
Effluent	38.2	21.5	19.6	18.4	16.7	11.2	45.3	1.806	.426	.146	.280	1.380	.033	.0016	6.38	3.90	6.86	4.115	200	7,800,000	200,000	1,518,300	73.8	69.6
Per cent. removed	15.86	7.33	45.3	32.72	24.40	11.2	45.0	1.440	.610	.435	.175	1.188	.050	.0026	6.15	4.40	....	....	1,106	Closed Sundays.		2,443,500	....	....
Sewage, April	47.1	43.0	17.3	25.7	19.1	4.3	28.0	1.993	.435	.143	.292	1.158	.050	.0026	6.18	4.40	....	....	998	14.41		.....	....	....
Effluent	60.3	43.0	17.3	25.7	17.3	12.3	39.7	1.769	.429	.156	.273	1.340	.028	.0026	6.25	4.27	6.75	3.651	941	1,018	—8.18	1,200,000	50.1	46.3
Per cent. removed	8.71	62.32	53.37	38.09	16.12	5.04	29.14	11.23	1.38	2.10	6.85	11.23	44.00	0.00	0.00	0.00	0.00	0.00	5.83	8,100,000	261,290	9,581,200	47.9	43.0
Sewage, May	63.8	42.5	21.3	20.4	10.7	10.1	14.33	1.785	.351	.126	.225	1.750	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	34.1	14.4	10.7	3.7	19.7	3.0	21.22	1.656	.306	.111	.195	1.350	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	18.35	22.59	33.5	25.0	38.3	7.0	20.0	11.02	2.0	1.6	13.3	22.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, June	58.2	31.6	17.6	14.0	26.6	18.4	29.1	2.044	.576	.200	.376	1.822	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	39.42	30.45	15.09	28.09	9.36	2.41	21.65	1.188	.418	.189	.229	.770	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	71.82	23.8	54.2	29.6	64.8	87.1	25.7	41.9	27.4	5.5	39.1	57.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, July	68.5	56.5	14.3	26.3	14.2	12.1	14.33	1.625	.306	.111	.195	1.319	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	21.31	38.60	12.54	26.06	51.47	50.82	36.78	1.194	.306	.111	.195	.888	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	68.9	31.7	12.54	26.0	51.47	50.82	36.78	1.194	.306	.111	.195	.888	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Sewage, August	100.1	68.2	31.9	36.3	26.0	5.7	44.23	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Effluent	67.5	51.4	16.1	27.7	14.3	11.53	45.64	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	32.57	24.63	57.53	23.76	45.0	0.0	3.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, September	100.2	69.6	30.6	35.4	30.6	23.4	39.4	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	49.0	23.4	25.4	18.0	25.6	16.2	21.15	1.656	.306	.111	.195	1.350	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	24.7	24.7	29.0	23.53	16.3	30.7	46.5	43.5	57.5	52.2	60.1	38.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, October	91.5	58.7	32.8	39.6	32.8	16.4	40.2	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	50.75	35.75	14.97	20.78	14.97	12.03	16.83	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	44.5	39.0	54.3	47.5	54.3	26.6	58.1	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Sewage, November	85.3	58.4	26.9	31.5	28.4	14.5	42.9	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Effluent	49.5	28.4	21.1	7.3	21.2	14.2	28.5	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Per cent. removed	42.0	51.3	21.5	76.8	25.7	2.1	33.6	14.6	41.2	23.3	49.7	5.9	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6
Average effluent, 1901-1	45.8	25.8	20.0	5.8	20.0	14.2	28.5	2.502	.424	.178	.246	2.078	.044	.0109	6.47	4.64	7.23	3.140	131	5.41		.....	....	....
Av. % sewage, 1901-1	44.5	20.8	17.2	3.6	23.7	14.3	28.5	2.930	.721	.232	.489	2.209	.033	.0016	6.38	4.87	7.45	3.707	200	28.72		1,518,300	47.4	42.4
Per cent. removed	25.71	10.33	30.29	38.44	33.85	11.55	6.82	22.17	44.33	23.28	53.17	5.97	0.0	0.0	0.0	0.0	2.9	15.3	34.5	8,100,000	261,290	2,767,800	49.3	44.6

Note.—The residual ammonia represents the difference between the sum of the free and albuminoid ammonia and the ammonia obtained by the Kjeldahl method for nitrogen.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The screening and washing of crushed stone or gravel to free it from all dust and small particles is commonly regarded by engineers as a necessity for the production of a high quality of concrete. Only a few years ago, in fact, it was the opinion of many engineers that the aggregate for concrete should be freed from all pieces much smaller than the maximum 1½-in. or 2-in. piece set by their specifications; in other words, uniformity in size of the stone fragments or pebbles was considered a desideratum in an aggregate for concrete. Successive experiments have quite completely proved that uniformity in size is not desirable, but that a better and stronger concrete is secured when the aggregate consists of fragments having a considerable range in size from the maximum down. Here and there a brave spirit has claimed that this range in size might be increased to include the run of the crusher without sensible injury to the resulting material, but general practice has held firmly to the belief that the dust and fine particles were better excluded than included.

This belief, as is well known, is based upon the notion that much of the finer material is mere dust and dirt of no value and that another part is made up of fine particles which, if they are not directly injurious, serve only to increase the sand constituent of the concrete to an unknown degree. The argument is a logical one, and most engineers to-day accept it without question. For this reason our readers will note with interest in the article on the concrete breakwater at Buffalo, N. Y., which is published in this issue, that the run of the crusher was used in making all concrete, with such good results that the able engineer in charge is constrained to remark that "he believes it is the best practice, and that engineers have for years been discarding from their concrete aggregates the best and most valuable parts of the broken stone." The conclusion, if it be generally true, is an important one, since it means a saving in screening and washing of the aggregate which in large works form an important item of the cost. It also means, if we are not mistaken, that a more careful inspection of the work of proportioning the concrete is necessary.

For example, on the Buffalo Breakwater work, with the materials there used, the sand element of the concrete was supplied from three sources, and the relative amount of the total obtained from each source varied at different times, so that a frequent readjustment of the nominal proportions was necessary to secure a constant composition. It is stated that no difficulty was experienced in doing this, and this is probably true, for work so well inspected and carefully done as was that at Buffalo, but would it be equally true on concrete work generally where the inspection and control were not so perfect? We do not propound this question as a rebuttal to the argument for the use of the run of the crusher in making concrete, but as an inquiry which many engineers may reasonably make before departing from the long-established and safe practice of screening and washing the broken stone aggregate. Whatever the final answer to the question may be, the successful experience of the Government engineers at Buffalo is of exceeding interest, and we bespeak its careful consideration by engineers.

Another variation from common practice in this work which is of less general importance, but which also deserves mention, was the use of the molding floor to form the bottoms of the molds in which the concrete blocks were cast. This procedure promises a saving in the cost of the molds and particularly in the rapidity and ease with which they may again be withdrawn and reset for use which engineers having work of this character in hand will do well to bear in mind.

And, by the way, if the run of the crusher is good enough to make concrete with, might it not also be good enough to make macadam roads with? How much of the sorting and screening and grading done at rock-crushing plants furnishing rock to roadway contractors is worth what it costs, and how much is only a tribute to past precedents and not to well-founded ideas?

Some of the complications which are likely to result where an engineering society secures legislation extending peculiar privileges to its members are suggested by the following item in the Montreal "Star," of May 20:

> The Canadian Society of Civil Engineers was yesterday ordered by mandamus to admit Mr. Louis H. Tache, who is now at Fraserville, Que., to membership in the association. The defence was that the petitioner was not a civil engineer, but a practicing advocate, duly inscribed on the rolls as such. Mr. Justice Lavergue ruled that it made no difference what other profession the petitioner belonged to, provided he had the necessary qualifications he was entitled to membership of the association on paying the regular fees.

The members of most American engineering societies, we fancy, would not relish the idea of turning over to the courts the decision as to the eligibility of new members.

RECENT EXPERIMENTS WITH THE SEPTIC TANK.

A notable addition to the knowledge of the septic tank method of treating sewage has been made by Prof. Leonard P. Kinnicutt and Mr. Harrison P. Eddy, of Worcester, Mass., in contributing to the annual report of the Connecticut State Sewerage Commission the admirable paper on "The Action of the Septic Tank on Acid Iron Sewage," which is given in somewhat condensed form elsewhere in this issue. While the paper appears on its face to be limited to a peculiar class of sewage from one city, yet in reality it includes a review of much of the available American and English data on the septic tank. On this account the paper is well worth the close study which it will doubtless receive from all interested in the subject.

The septic tank in question was a small, tightly closed cylinder, with a capacity of less than 1,800 gallons. For some reason which we do not understand, unless it was to avoid confusion, Messrs. Kinnicutt and Eddy make no reference to the fact that during the whole period covered by their observations on this small closed tank, sewage from the same source was being treated at Worcester under Mr. Eddy's charge in an open septic tank of 350,000 gallons capacity. Fortunately, the operations of the large tank are reviewed by Mr. Eddy in his last report as superintendent of sewers for Worcester. His review, while brief, is accompanied by a valuable table of results. This table is reprinted on page 81 elsewhere in this issue, together with an abstract of that portion of Mr. Eddy's report dealing with the subject in hand.

It should be kept in mind, in examining the results obtained with both the small closed and the large open tank at Worcester, that the sewage treated is, as the authors of the first paper state clear, largely composed of manufacturing wastes containing large quantities of sulphuric acid and iron. The results, therefore, are not as favorable in some respects as those obtained with an ordinary domestic sewage. The large tank, we may add, is perhaps not a thoroughly representative type of open septic tanks, having been built primarily for chemical precipitation. In this respect the results obtained by Mr. Geo. A. Carpenter (see Engineering News, Dec. 20, 1900, and Feb. 27, 1902), at Pawtucket, R. I., with a settling reservoir used as a septic tank, are also, perhaps, somewhat unfair to the newer method of treatment. The same statement applies with even greater force to the use, some time ago, of the sewage receiving reservoir at Brockton, Mass., for septic treatment (see Engineering News, pp. 66 and 72, July-Dec., 1899). But notwithstanding their limitations all these studies have been and continue to be very instructive.

The investigations carried on with the small closed tank at Worcester are compared by Messrs. Kinnicutt and Eddy with some of the results obtained by Mr. Carpenter at Pawtucket, and by numerous observers in England, as well as with the detailed and valuable exhibits of work done at Lawrence, Mass., and published in the reports of the Massachusetts State Board of Health for the years 1898, 1899 and 1900. Altogether, so much comparative data is presented as to comprise a comprehensive review of the septic tank process to date, excepting the omission, as already stated, of Mr. Eddy's own work with the large open tank at Worcester.

Two important phases of the work done by Messrs. Kinnicutt and Eddy were their studies of the gases evolved by the tank and the residual, or sludge, at its bottom. They propose to continue their investigations of these subjects, and it is to be hoped that others will take up the work. Of course, much of this has already been done at Lawrence and more is to be expected there, but Worcester and Lawrence are practically alone in this field.

One of the most striking things about the published studies of the septic tank abroad is the meagerness of most of the analytical data. In fact, this holds true generally for all classes of sewage purification in England. It seems strange, also, that so little has been heard of late regarding the septic tank at Exeter, England. For two years or so after its installation, the depth of sludge in the tank was reported from time to time, but the reports seem to have stopped some time ago. How many times, if at all, the tank has been cleaned out, we cannot say.

A careful reading of the comparative results obtained by the different septic tanks reviewed by Messrs. Kinnicutt and Eddy, combined with Mr. Eddy's rather sceptical remarks about the septic tank is his annual report, make it very clear that there is much to be learned about the septic tank before it can be considered as on the same plane of certainty as the older processes of sewage treatment. Very little is known regarding what most of the numerous septic tanks in this and other countries are really accomplishing, or how successfully they may be operated for five or ten years in connection with other and more complete methods of sewage purification. A series of chemical observations no longer than those at Worcester and Lawrence show such veriations from month to month and season to season as to

prove that the few brief observations reported from other installations are liable to be misleading in the extreme. What data have we to show with any conclusiveness the amount of sludge to be expected from a large installation of septic tanks and the most economical method for its disposal? Who can say, at least for American conditions, whether a septic effluent can be most thoroughly purified for five or ten years to come by intermittent filtration, by contact beds, or by continuous filtration? Is it not a great mistake to assume that a small city or village can afford to install septic tanks and some of the various new so-called bacterial filters when most conservative American engineers hesitate to recommend such systems for large cities? These questions are asked, not so much to throw doubt on the value of the septic tank as to call attention to the fact that we need more such valuable studies as those presented elsewhere in this issue, and as are being made at Lawrence; and also to emphasize the desirability of having systematic observations carried on by competent men at a much larger number of these newly-established plants.

LETTERS TO THE EDITOR.

Use of an Adding Machine for Engineering Computations.

Sir: Having occasion recently to make up the preliminary estimates of quantities and cost for a projected railroad, and being pressed for time, it occurred to me that an adding machine might be used to advantage; and the experiment resulted so satisfactorily that a note relating to it may be of interest to other engineers.

The machine was used principally for computing the quantities of excavation and embankment. One assistant, with the profile before him, called the depth of cut or fill; another, with the ordinary table of quantities and the adding machine (comptometer), took out from the table the corresponding quantity in cubic yards and operated the number into the machine. When any cut or fill was completed, the sum of its contents was shown by the machine, called off, and recorded on the profile, as usual. When a section was thus completed, the quantities in the several cuts and fills were called off, added by the machine, and the sum recorded. It was found that the two assistants were able to cover easily double the quantity of line that they could without the machine. Items of work other than grading were handled in the same way. The idea may not be new, but those who have not tried it will find the machine a great saver of time and labor.

S. Whinery.

95 Liberty St., New York, May 21, 1902.

A Curious Instance of the Resistance of Oak Timber to Decay.

Sir: I inclose herewith a picture which may interest the members of the profession. It shows an old cannon which has stood on the high ground of Pt. Bonita, or northern headland of the Golden Gate, or entrance to San Francisco Bay, since about 1850, doing duty as a

Cannon Used for Fog Signal at Point Bonita, San Francisco Bay, Since About 1850, Showing Comparative Resistance of Oak Timber and Iron to Destruction by Sea Air.

light and fog signal. It was placed there before the lighthouse was built, and was fired to sea at night in 20-minute intervals. Its interest lies not so much in the fact that it was planted there upon the advent of the Argonauts on this coast, but that it illustrates in a striking way the value of oak as a material in engineering construction. The woodwork of the wheels, felloes, spokes and hub is in a perfect state of preservation even where the earth is in contact with felloes; the timber is likewise solid and unaffected by the long exposure to the moisture-laden atmosphere. Upon examining the ironwork, however, it will be observed that it is practically all gone. The axle and nut have rusted away an inch or more; the tire is eaten away in numerous places; and straps, nuts, and bolts have about disappeared. The point to which particular attention is directed, however, is the piece itself. These early cannon were made of the best tough gray cast iron—some recently broken up in this harbor have been found chilled for half their distance through. The rusting on the cheeks of this piece is very marked, and is, I should say, at least ⅜-in. in depth. California redwood is supposed to possess superior resisting powers where exposed to moisture, and does generally stand well, but in tearing out the timber platforms of old gun emplacements to make way for modern works, redwood timbers, 12 × 20 ins. in size have been found to be completely rotted away. Very respectfully,

J. H. G. Wolf, C. E.

United States Engineer Office, San Francisco, Cal., April 28, 1902.

Standards of Accuracy in Spirit Leveling.

Sir: In your issue of April 24, 1902, p. 340, you give an extract from the last report of the State Engineer and Surveyor of the State of New York, setting forth that in certain spirit leveling operations carried on under his direction:

Duplicate lines of levels shall be run forward and backward and the error of closure of the two runnings shall fall within 0.020 ft. $\sqrt{}$ (Distance in miles between benches), or the lines shall be re-run.

This limit was subsequently reduced to 0.016 ft. $\sqrt{}$ (distance in miles between benches.)

Again, in your issue of May 1, p. 353, you print a letter from Mr. Cyrus E. Babb, apparently an assistant in the U. S. Geological Survey, in which that gentleman says that the degree of accuracy customary in the regular leveling work of the topographical division of the Geological Survey is 0.5 ft. $\sqrt{}$ (distance in miles.)

From these statements it appears that the degree of accuracy required in spirit-leveling by the New York State Engineer and Surveyor is more than 31 times greater than that required by the U. S. Geological Survey—which is certainly very surprising.

I am writing away from all my books of reference, but if my memory is trustworthy the accuracy required by the New York State Engineer and Surveyor is just about that usually attained in the best lines of spirit-leveling run by the great national surveys of the world. It would be interesting to know how the standard of the U. S. Geological Survey compares with average railway work, but I do not recollect ever seeing any authoritative publication as to what the latter really is. There must be ample data for determining it in the principal offices of many of the great railways of the country, and it would be time well spent if some of the able engineers having access to these papers would work out the result and make it public. Very respectfully,

Wm. Harkness,

90 Mercer St., Jersey City, N. J., May 5, 1902.

The Separation of Oil from Condensed Steam.

Sir: In the able and comprehensive article under the above title by Mr. J. R. Bibbins, in your issue of May 22, he opens a discussion as to the means for the most effectual separation of oil from condensed engine steam. To begin with, he asserts, as a result of his search for evidence along the lines of his exhaustive experiments, "that the actual separation of entrained oil had never been obtained on a large scale." As one deeply interested in the problem of the recovery and purification of condensed steam, the writer wishes to challenge this assertion, having made thorough tests of efficiency of the methods of purification in use at the following plants: Pumping station of New York Transit Co., Horseheads, near Elmira, N. Y.; Elizabeth plant of United Electric Co. of New Jersey, Elizabeth, N. J.; and at the yards of the Gas Engine & Power Co., and Charles L. Seabury & Co., Consolidated, at Morris Heights, New York city.

The test of the New York Transit Co.'s plant was made in August, 1899. The system in use consists of a combination of oil separating and water softening processes, which are carried out simultaneously in a single apparatus. Instead of treating the emulsion alone with a large excess of milk of lime and using the lime water thus produced to soften the make-up water, a mixture of all the condensed steam and the requisite amount of make-up water, which in this case is hard, is treated with lime water in sufficient amount to remove the temporary hardness, no excess being added at any time. On account of the permanent hardness in the make-up water, a certain definite amount of sodium carbonate is also added. At this particular power plant it is important to waste as little water as possible, hence all oily drips are mixed with and purified at the same time as the condensed engine steam. The removal of oil is complete. At the time of a recent visit the boilers were in perfect condition—the only true test of any system of purification.

The problem at the plant of the United Electric Co. of New Jersey's plant is somewhat different. On account of the fact that dilute sewage was originally used as make-up water, ferrous sulphate was added to insure perfectly clear treated water. In other respects the method used is identical with that in use at Horseheads.

In the above instances both of the make-up waters are hard. If, however, soft make-up water is obtainable, as at the steam plant of the Gas Engine & Power Co. and Charles L. Seabury & Co., Consolidated, the use of lime may be dispensed with without impairing the excellence of the results.

It is evident in Mr. Bibbins' process that the oily emulsion is converted into saturated lime-water, which he proposes to use in softening make-up water. It is also evident, however, that, taking as a basis for calculation the most recent analysis of Detroit River water, quoted by him, the amount of lime water necessary to treat the make-up water is only 2% of the total make-up water. If this be estimated liberally at 20%, it will be seen that an amount of lime water equal to but 0.4% of the total boiler feed-water is required. The difference between this amount and the total oily emulsion clarified by lime must be either thrown away or fed into the boilers as dilute lime water, which is certainly a questionable procedure.

In view of the fact that in the cases cited the same result (removal of oil from condensed steam) can be obtained without depending on the quasi-efficiency of the average mechanical oil separator, without introducing lime into the boilers and without waste of water, it would appear that the utility of Mr. Bibbins' process is very limited.

L. M. Booth,
Industrial Water Co.

126 Liberty St., New York city, May 23, 1902.

The Causes of Settlement and Warping of Concrete Piers.

Sir: I note the letter of Mr. W. H. Kutz in the May 8 issue of Engineering News in regard to piers built in freezing weather. During my nine years' experience in structural concrete work I have had some cases, which I think will explain the settlement of piers, and may throw some light upon the horizontal movement.

In 1897 I built, at the Watertown Arsenal, 38 piers, 1 ft. square, varying from 2 ft. to 14 ft. in length, for test purposes. All these were built in midwinter in an unheated lumber shed, the temperature averaging 10° above zero. The concrete was mixed as wet as it was possible to be without quaking when tamped. It was spaded on the face of the molds and very thoroughly rammed. The full height of the piers was filled in one continuous operation. The method of mixing and placing the concrete was very much the same as Mr. Kutz's, the materials being machine mixed.

Some of the piers were close to a door and froze as soon as placed; others were well inside in front of windows with a southern exposure and did not freeze so soon. In the piers which did not freeze, the following morning I noticed settlement of from ⅛-in. to ½-in. in the concrete. Those which did freeze did not settle at all. Ever since I have observed when a large depth of concrete is filled in at any time it has settled from ⅛ to ½-in. the next morning, and I have become accustomed to expect this and allow for it in filling work to any given height.

I think in the case of bridge piers the south ends were kept warm by the sun sufficiently to settle, while the other end, which must have been colder, froze so that they could not settle, which would also be counteracted by the expansive force of freezing water. The permanent difference of level is due to the fact that in the south end, which settled, the concrete is denser than in the north end, which did not settle. It is a curious fact that thoroughly rammed concrete will settle, due to its own weight.

As a large part of my work is structural concrete in connection with buildings where true lines and appearance are of much more importance than strength alone, special attention has been given to centering. I have never used Oregon fir for centering, but presume it is very similar to our eastern spruce. Wherever true lines are required I have abandoned the use of spruce, because being wet on one side and being exposed to the air or sun on the other, it invariably warps and distorts the work. I use exclusively for important exposed work white pine or cypress, which will withstand the action of water on one side and air on the other much better, and, in addition, give it one or two priming coats of paint; and I often in addition coat the surface with vaseline to prevent the wood absorbing water. In this way distortion is avoided.

I presume as the southwestern face of the piers in question were under the direct rays of the sun during the highest temperature of the day and until the end, the west side was more distorted than the east side or north end.

No mention is made of the use of salt in the water. This is a great equalizer in the setting of concrete, making the setting more uniform. I invariably use it in cold weather, and very frequently in midsummer, to avoid

the unequal effect of the exposed side drying more rapidly than that which does not receive the direct action of the sun.

Yours truly,

Leonard C. Wason,

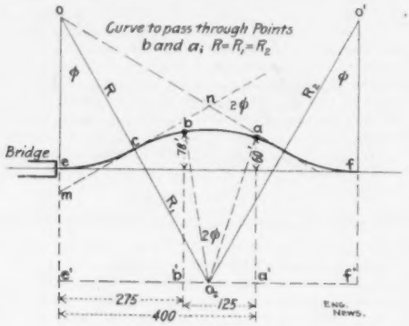
President and Manager the Aberthaw Construction Co.

8 Beacon St., Boston, Mass., May 13, 1902.

(We are sure our readers will appreciate the value of the above letter and that we speak their minds in extending to its writer the thanks of all engineers interested in concrete construction—and what engineers is not, nowadays? This is just the sort of practically useful information whose interchange is of the greatest value to the profession, and we desire to make this journal the medium for such interchange to the greatest possible extent.—Ed.)

Solutions of Curve Passing Through Two Fixed Points.

Sir: I notice in Engineering News for April 24, a curve problem, submitted by E. M. Layfield. I offer the following solution, which is very much simplified by reason of the fact that the center angles of the central and end curves are respectively 60° and 30°.



$mc = cn = R \tan \phi$

in Δonm, $\angle onm = 2\phi$

$\therefore 6\phi = 180°$ or $\phi = 30°$

$2\phi = 60°$

Draw $e'f'$ through o_2, parallel to ef

then $(o_2a')^2 + (aa')^2 = R^2$

and $(o_2b')^2 + (bb')^2 = R^2$

or $(o_2a')^2 + (aa')^2 = (o_2b')^2 + (bb')^2$

Substituting values in above equation

$(400 - R)^2 + (2R\cos\phi - R + 60)^2 = (275 - R)^2 + (2R\cos\phi - R + 78)^2$

$\therefore R = \frac{81891}{214 + 36\sqrt{3}} = 296.33$

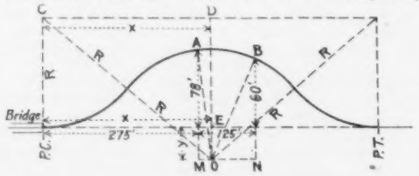
The accompanying sketch and computation indicate the method of obtaining the value of R. Yours respectfully,

E. F. Ackerman, Chief Draftsman.

Chief Engineer's Office, Lehigh Valley R. R. Co.,

South Bethlehem, Pa., May 12, 1902.

Sir: The problem in railroad curves given by Mr. E. N. Layfield, in your issue of April 24, 1902, which is shown by the accompanying sketch, may be solved analytically



Curve to begin at Bridge and pass through Points A and B.
Required R.
Let Distance from P.C. to E = x.
Let O E = y.
The Curve is symmetric about O D.

as follows, it being desired to make the radii of the three curves the same:

From rt triangle A M O; $(y + 78)^2 + (x - 275)^2 = R^2$. (1)
From rt triangle B N O; $(y + 60)^2 + (400 - x)^2 = R^2$. (2)
From rt triangle C O D; $x^2 + (R + y)^2 = (2R)^2$. (3)

Combining (1) and (2)

$$250\,x + 36\,y - 81.891 = 0;$$

or

$$x = 327.564 - 0.144\,y. \quad (4)$$

As the solution of these equations direct would lead to high powers for the unknowns and large numerical coefficients, it is easier to solve by trial. Assume a value for y, obtain the x corresponding by equation (4), then get R by either equation (1) or (2), and substitute these values in (3) to see if it is satisfied.

With a slide rule, a table of squares and a six place logarithm table, a few trials gave

$y = 219.15$; $x = 296.01$; $R = 297.89$.

From these values all the properties of the curves may be easily computed.

Respectfully,

Noah Cummings.

252 W. 135th St., New York, May 17, 1902.

The Plane-Table for Small Topographical Surveys.

Sir: Land valuations are based upon the world's population, limitless and unknown. From my camp—a speck upon the wide rolling prairie—I can see leagues of land worth $50 an acre to-day which was not worth a survey 40 years ago.

The only imperishable legacy bequeathed to posterity is real estate and man is so blind and oblivious to the future that he does not foresee the litigation likely to arise from improper descriptions and inaccurate surveys.

The remedy, I believe, will be found in the topographical survey in which natural objects of all kinds are noted. The magnetic bearings and distances are insufficient for the retracing of lines. You may ask how in practice can we console the employer when a month is spent in making a survey which in his opinion should be done in a week. Simply by enclosing with your bill a map in detail of the land. 'Tis gratifying to watch an old colonist peruse for the first time a map of this kind. There is not a brook, fence or roadway which does not hold a memory dear to him. Upon a dozen walls in as many states in simple frames, hang plats of land surveyed and subdivided during my short experience. A family with such a map before them is less likely to appeal to the courts to settle a dispute over land boundaries than one without it.

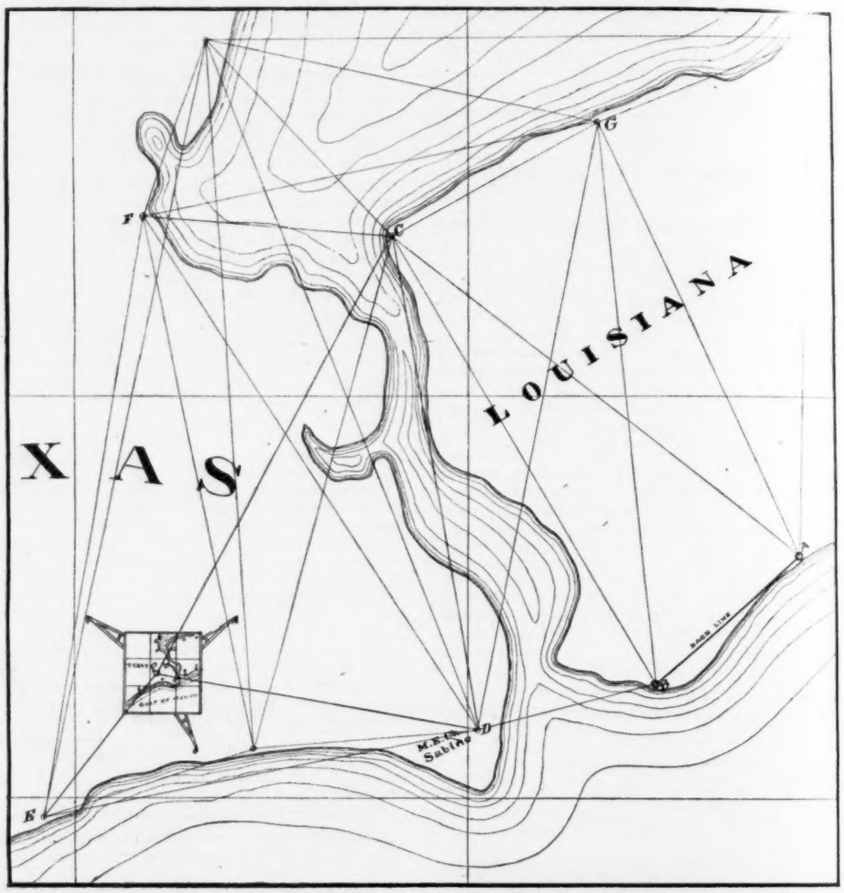
In making topographical surveys, I use the transit and plane-table as shown in Fig. 1. I repeat the angles; i. e., after noting the first reading allow the deflection to accumulate on the plate five or six times then divide the product or final reading by the number of times repeated, and we have the correction for the first reading. This makes it possible with the ordinary transit, to close the triangles within 1′ of 180°.

However, small the locality, the three principal triangulation points should be so constructed that they can be occupied with the instrument, and the closing error should be adjusted before beginning computation. Such points as church steeples, chimneys, etc., can be cut in from these principal points and afterwards located on the projection for the use of the plane-table as it is necessary to see three points to find "position," which is quickly done from the trial plan.

First approximate your position on the sheet, then bring your table as near as possible to a true meridian. Then with the rule of the alidade we bring point C in range with approximate point and C on projection, and the same with D and E. The intersection of these lines will form a triangle inclosing the true position P and its position from either of these intersections is in proportion to the corresponding side. This is estimated again and the table brought very nearly to its true meridian by screw and again the triangle is inscribed, but much smaller and so on. The topographer in a few days very expert at this.

The stadia should only be used in taking and the front end of the steel rule of the al equal focal distance or constant of telescope ures should be taken from there instead of fr ter. Prominent points in the field should fi pied and a flag left at those which can be used There is no necessity for finishing the work but it can be closed in gradually from the manding elevations of the field, which dispense clearing out in a wooded district.

Plumb bobs, compasses and steel tapes are whatever in plane-table surveying. When quired for leaving a pole or backsight at the can be found by swinging the steel rule between and sighting from P to the ground from two po



SKETCH ILLUSTRATING USE OF THE PLANE TABLE IN TOPOGRAPHIC SURVEYING.

When meters are used for the horizontal scale and feet for the vertical, use this formula

$$\left\{\frac{\text{D, meters} \times \text{angle, minutes}}{1\,000}\right\} - .022$$

= elevation of depression in feet.

Where the ground is uneven and great accuracy depends on the stadia measurement, the face of the rod must be held at right angles to the visual angle or if held vertical use this formula:

$$\tan \tfrac{1}{2}\theta = \frac{C'E}{EF} = \tfrac{1}{2}\frac{s'}{1};$$

where

θ = visual angle;
s = space intercepted on rod; and
E F = the horizontal distance;

or

$$\frac{C'D'}{s} = \cos^2 a,$$

where a = angle of inclination of the line of collimation

Yours truly,

W. P. Bullock, C.E.

Letot, Tex., April 3, 1902.

Another Formula for Estimating Concrete.

Sir: Since the publication of Rafter's Tests,* giving the amounts of mortar and concrete resulting from the mixture of given portions of cement, sand and stone, the

*"On the Theory of Concrete," by Geo. W. Rafter, M. Am. Soc. C. E., Trans-Am. Soc. C. E., Vol. XLII., pp. 103-154.

writer has felt the need of a formula by which the same quantities could be estimated for other compositions not given in the tables referred to, the data of the tables forming the basis for the formula of extension. The formula given by H. P. Gillette in Engineering News, Dec. 5, 1901, is along this line, and while it gives results agreeing fairly with the tests, yet it seems to me it is based on erroneous assumptions. Mr. Gillette states, apparently referring to ordinary concrete, that "broken stone, like sand, has about 20% of its voids unfilled, or there occurs that amount of increase in its voids upon adding mortar." On this basis he assumes in his formula that the volume of mortar required to fill the gross voids in broken stone or gravel is only 80% of the volume of those voids, and similarly for sand voids, filled with cement. In other words, about 1-10 the volume of the finished concrete is unfilled voids.

It is no doubt a fact that mortar and concrete are more

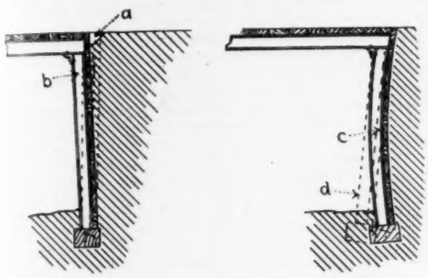


Fig. 1. Fig. 2.

Figs. 1 and 2. Diagrams Illustrating Deflection of Supports of Leg Bridge.

or less porous, and also that the volume of mortar required to fill the voids in loose broken stone is less than the volume of those voids measured loose and dry. The explanation of the latter statement is, I think, quite different from the hypothesis of Mr. Gillette. Experiments by Rafter* on the stone used by him in his concrete cubes showed the average voids when measured loosely shaken in a cubic foot box to average 43%, while the same stone when rammed and lubricated as in concrete showed only 37% voids. In his tests of concrete, where the mortar was barely in excess of the amount required to fill the voids, the final volume of concrete was almost invariably less than the volume of stone used to make it; clearly indicating that the voids, and hence the gross volume of the stone are less in concrete than out, instead of greater as stated by Gillette. The same reasoning applies in the case of sand, as Rafter's tests show an average of 31.5% voids in loose sand and only 24% in wet packed sand. The general idea being that the unguous mortar allows the particles of sand and the pieces of stone to slide more closely together in mortar than do their more frictionable corners and surfaces in the loose pile.

Let k = volume of neat cement paste made from one volume of loose cement, ordinarily k = 0.94, but varies with the brand of cement and plasticity of the mortar.
V = voids in sand as measured in bulk = .315 in Rafter's tests.
v = voids in sand, wet and packed = .24 in Rafter's tests.
V_1 = voids in stone, measured loose, = .43 in Rafter's tests.
v_1 = voids in stone unguous and rammed = .37 in Rafter's tests.

$$m = \frac{\text{volume of packed wet sand}}{\text{volume of loose dry sand}} = 1 - (v - v_1)$$

= .925 in Rafter's tests.

$$n = \frac{\text{volume of unguous packed stone}}{\text{volume of loose bulk stone}} = 1 - (V - V_1)$$

= .94 in Rafter's tests.

In the tests referred to the sand which is here spoken of as dry was not laboratory dried, but resembled in condition that used in practice and varied in the different samples tested.

1: b: c is the volumetric formula for the concrete ingredients measured loose.

M = the volume of mortar which unit volume loose cement will make.
M = b m + excess of paste not required to fill net voids in sand, if any.
= b m + (k − v b m) (1)
C = volume of concrete made = c n + excess mortar not required to fill net voids in stone, if any.
= c n + b m + k − v_1 b m − V_1 c n
= k + b m (1 − v_1) + c n (1 − V_1) (2)

Equation (2) is similar in form to the denominator of Gillette's formula. Rafter made six tests of concrete composed of plastic mortar in the proportion 1: 2, and such an amount of stone that the mortar was 33% of the gross volume of stone, the resulting average proportions of the concrete being 1: 2: 6.25.

By the above formula, using the constants given, the resulting volume of concrete should have been 6.01 cu. ft. per cubic foot loose cement. Gillette's formula gives 5.54 as the volume of concrete, and the average volume obtained in the tests was 5.80.

The slight discrepancies may readily be accounted for by the differences in volume of mortar obtained in different tests by mixing the same proportions of cement and sand, as shown by Rafter's tables. The above example shows clearly that it is not necessary to assume the existence of any unfilled voids in designing concrete, as such did not exist in any sensible degree in the rather lean concrete described. It furthermore appears to me a very dangerous proposition to allow a contractor to assume that about 1-10 volume of the concrete is to be unfilled voids.

It also appears desirable in designing concrete to know beforehand both the volume and voids of the stone and sand when measured loose and when lubricated and compacted as in a concrete mastic. Rafter's tables may be safely used to determine volumes of mortar and concrete made for such sets of proportions as they cover. The formulas given afford a means of extending the tables for other mixtures and other brands of cement. The formulas also indicate the importance of determining the volume of mortar which can be made from the given proportions of sand and cement before deciding upon the number of volumes of stone to use, which may then be made such that the net voids will be filled, leaving a moderate excess of mortar to allow for unavoidable inequalities of distribution in the concrete beds.

Very truly yours, Robert E. Horton.
75 Arcade, Utica, N. Y., April 12, 1902.

*Report of State Engineer and Surveyor of New York, 1894, pp. 336-337.

The "Leg Bridge" Again.

(In our issue of May 8 we printed a letter signed "Bridge Builder," defending the "Leg Bridge," which was criticised by Mr. Daniel B. Luten in a contribution printed in our issue of April 17. A proof of "Bridge Builder's" letter had been submitted to Mr. Luten, with an invitation to reply to the same, and the publication of the letter before Mr. Luten's reply had been received was due to an oversight. We therefore reprint the letter below, together with Mr. Luten's reply.—Ed.)

Sir: My attention was attracted by Mr. Luten's article on "Defective Bridge Construction in the Prairie States" in your issue of April 17.

I wish to say that while all bridge engineers are aware of the theoretic defects of the leg bridge, there is a strong demand for them, and we will undoubtedly build them as long as the demand continues. They are usually chosen, not for really economical reasons, but on account of their lower first cost, where the funds are limited and a great number of bridges are required.

While a probable expansion of ½-in. in the length of a 60-ft. bedstead truss might seriously affect the calculation

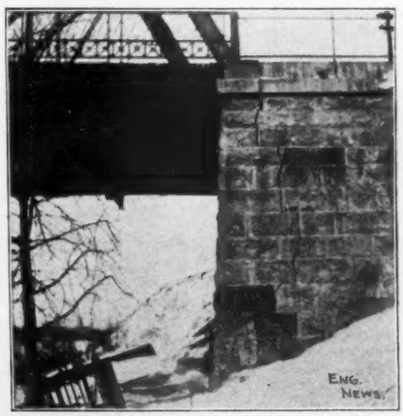


Fig. 3. A Bridge Abutment Cracked by Temperature Stresses in the Span.

of the stresses and the members, it is ludicrous to think that two earth embankments will not give enough to allow 20-ft. steel joists to expand ⅛-in., 1-16-in. at each fill. If the joists and legs are properly proportioned at the beginning, what matter if the bottoms of the legs are pushed in a few inches? It will not cause any additional or indeterminate stress in either the legs themselves or the joists.

I prefer to proportion the legs for a fluid pressure through their entire length and connect the joists to a cap over the top of the legs without knee braces. This permits the slight movement of the legs, and while there may be conditions conceived that will cause the bridge to become lopsided and that it will fall down, the cases where this is true are extremely rare.

Perhaps when the gentleman has succeeded in convincing the public that a certain concrete arch with wooden ties in the bed of the stream is more enduring and more economical and satisfactory, the counties will be rich enough to replace all their leg bridges with the arches referred to, and we will then be obliged to stop the building of leg bridges.

Yours truly,
April 24, 1902. A Bridge Builder.

Sir: In reply to the questions raised by your correspondent, "A Bridge Builder," I beg to explain more fully certain statements contained in my article on "Defective Bridge Construction."

Your correspondent asks: "What matter if the bottoms of the legs are pushed in a few inches?" No matter, provided they stop there; but after they have been pushed in a few inches there is no essential change in the existing conditions, and we might with equal justice repeat, "What matter if they are pushed in a few inches farther?" And, finally, "What matter if they finally meet in the middle of the stream?"

Fig. 4. Concrete-Steel Highway Bridge Near Lafayette, Ind. Span, 10 ft.; Cost, $233.

Reference to Figs. 1 and 2 will explain more fully why these legs are not stable; in Fig. 1, a shows the position of the top of the upright leg at time of erection; with a fall of temperature, the floor joists shorten and the legs assume the new position b. Now, unfortunately for the bridge, this happens at the worst period of the year, when frost and high water, both of which can readily penetrate to the earth backing, will force the earth of the embankment into any fissure, however small, to bear securely against the backing of the legs in their new position; the earth filling will necessarily encroach upon the span whether the contraction of the joists be 1-16-in. or ⅛-in. With increase of temperature the tops of the legs are forced back towards their original positions, and, as the writer pointed out in the original article, the bank is compelled to yield to their pressure, but mainly at the top. The legs will necessarily assume the curved position shown at c in Fig. 2; and the legs will bend whether they be proportioned for the equivalent fluid pressure, or for ten times that pressure, it being merely a question of degree; for the earth embankment while incapable of exerting an active pressure as great as the fluid pressure against the backing, can offer passive resistance to the motion of the legs many times in excess of that amount. The tendency of the curved beam to straighten throws the foot out and the leg takes a step into the stream, the final position being shown at d, of course greatly exaggerated. This process is repeated with each recurring change of temperature.

It seems to me that your correspondent is clearly wrong also in omitting the knee-braces, which not only resist this action of the legs, and consequently defer failure, but also counteract the moments in the floor joists due to applied loads. While it is impossible to compute their strengthening effect, he nevertheless sacrifices a possible factor of safety by omitting them.

I would add further that the above defects of the leg bridge are not purely "theoretic defects," as your correspondent's words might imply, but are actual, practical, existent, facts. I can produce photographs of a leg bridge with the legs forced in at the bottom, and the 4-in. stone backing behind the legs cracked and fissured from top to bottom, yet with wings of 2-in. planks held to place by two strands of telegraph wire under the roadway from wing to wing! If it is desired, I can give numerous specific instances of failures of this type of bridge, but I do not wish to do so because of the reflection on the builders.

I will, however, present a photograph, which, while not of a leg bridge, clearly shows the forces at work to accomplish the destruction of such bridges. Fig. 3 is a view of the east abutment of the Main St. Bridge across the Wabash River at La Fayette, Ind., erected about 1890. The rollers under one truss have become fixed, and the temperature changes in the truss have pulled the top of the stone abutment away from the wings, breaking the bond through several of the stones. In about three years' time this crack has grown to a width of 1½ ins. at the top. That the crack is due to temperature changes in the truss, and not to pressure of earth filling alone is evidenced by the fact that the crack runs out at the toe of the abutment, instead of following its back line. There is, moreover, no displacement of the wings from the earth pressures behind them. Unless repairs are made, and that

soon, there is every reason to believe that the structure will fall into the river in the course of a few years, either by the overturning of the abutment, or perhaps by its being forced out at the bottom.

Finally, leg bridges are built not because of lack of funds on the part of the purchaser, but rather because of lack of appreciation of their defects and limitations, which is apparently shared to some extent by bridge engineers. If cheapness were so important a consideration, it is hard to see why wooden bridges are not built instead.

Since your correspondent has raised the question of cost of concrete arches, I submit Fig. 4 for your consideration, a concrete-steel bridge of the type described in your issue of May 8, located near La Fayette, Ind., of span 10 ft., width of roadway 16 ft., and erected at a total actual cost of $233.

Very truly yours, Daniel B. Luten.

The National Bridge Co., Indianapolis, Ind., May 13, 1902.

Notes and Queries.

In our issue of March 27 (p. 241), a brief item was published stating that a concrete arch of 200 ft. span was to be built near Danville, Ill., on the Peoria division of the "Big Four" R. R. Our correspondent who furnished us the information now writes us that he was misled and that the structure will have two arches of 50 ft. span. He also informs us that the work now in progress is being carried on with the aid of a traveling cableway. The cableway towers are supported on trucks which travel on tracks laid parallel to the stream, thus enabling the cableway to cover any point in the area between the tracks.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF MICHIGAN.—The University Bulletin, Vol. III., No. 2, announces the establishment of a series of courses in higher commercial education. These include special courses in commercial law, economic geography, commercial and industrial history, the application of the principles of chemistry, physics and mathematics to industrial undertakings, the study of accounts, organization and administration of industries, private and corporate finance, etc. The bulletin referred to can be secured by addressing Prof. Edward D. Jones, Ann Arbor, Mich.

RENSSELAER POLYTECHNIC INSTITUTE.—Director Palmer C. Ricketts announces the following changes in the departments of physics and electricity, for next year: Former Professor of Physics and Electricity Wm. Lispenard Robb, Ph. D., of Trinity College, will occupy the chair of physics and electrical engineering at the Institute. Prof. Robb has been consulting engineer of the Hartford Electric Light Co. for ten years, and consulting electrical engineer for the New York Shipbuilding Co. for three years. As assistants he will have—Mr. E. D. N. Schulte, B. S., E. E., and Mr. H. H. Rudd, B. A. An addition is to be made to the chemical laboratory building this summer, to provide laboratories for water analysis and special quantitative work. Dr. John M. Clarke, New York State Paleontologist, will be Professor of Mineralogy and Geology.

THE ABOLITION OF GRADE CROSSINGS at Cincinnati, O., is again to be considered by the city authorities, under the new state law. Under the old law it was optional with the railway companies whether they would agree with the city as to work of this kind, but under the new law the Board of Legislation (or similar boards in other cities and towns) can compel the railways to co-operate with the city authorities in this matter. The board can require the companies to prepare plans and specifications and submit them for the approval of its engineer. If they fail to do this within six months after receiving notice, the board can direct its engineer to prepare plans and specifications, which would be submitted to the companies for approval. Should they fail or refuse to accept them within three months, the city is authorized to appeal to the Circuit Court, which is made the final arbitrator. Should the court decide that public safety demands the abolition of the crossings, and that the city's plans for the work are practicable, it can order the companies to co-operate with the city in carrying out the work. The cost is to be equally divided between the city and the company or companies. Where electric railway tracks are involved, the railway is to pay 50%, the city 25%, and the street railway 25%. Mr. E. Breen, Superintendent of the Department of Track Elevation and Subways, proposes that the railway companies be invited to have their engineers co-operate with him in the preparation of the plans in the first place, instead of the city and the railways preparing separate plans to meet their own ideas and then trying to harmonize them afterwards. There are over 100 dangerous grade crossing in the city.

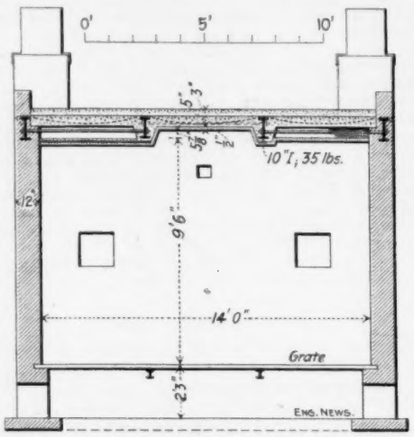


Fig. 1. Transverse Section of Test House Fitted with Lock-Woven Metal Concrete Floor.

THE SEMI-CENTENARY OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The thirty-fourth annual convention, celebrating the fiftieth anniversary of the founding of the American Society of Civil Engineers, was held in Washington, D. C., on May 20-23 inclusive, with headquarters at Willard's Hotel. It was the largest meeting of the society ever held, as about 325 members and 380 guests were in attendance. The convention was opened on Tuesday morning by an address of hearty welcome from Hon. H. B. Macfarland, President of the Board of District Commissioners. Rear Admiral George W. Melville, U. S. N., then addressed the members on behalf of the local committee, and especially pointed out the many advantages possessed by Washington as a place of meeting for engineering societies; and he suggested that it would be well for the American Society of Civil Engineers to hold its annual convention there at least once in ten years, as no other city in the United States could so well emphasize the national features of such an organization. Mr. Charles Warren, the Secretary of the society, presented a brief but interesting resumé of the principal events in the [illegible] years of the existence of the society, commencing with incidents marking its founding in 1852. In this connection Mr. Hunt brought out the interesting fact that the first secretary of the society and the sole survivor of the "founders," Mr. Robert B. Gorsuch, was still living and practicing his profession in the City of Mexico. Mr. Craighill appropriately moved that a telegram be sent to Mr. Gorsuch from the convention, in memory of his early services and congratulating him on his long and honorable career as a member of the profession. The business exercises were closed by the annual address of the President of the society, Mr. Robert Moore, of St. Louis, who spoke of the future of civil engineering and the character of the engineer of the Twentieth Century. This address was published in full in our last issue.

The local committee had arranged an exceedingly attractive program for the members attending the convention and the first excursion—of Tuesday afternoon—a trolley ride to the famous Cabin John Bridge. The Tuesday evening local engineering features were presented to the convention in the form of a series of talks illustrated by lantern slides. These were as follows: "Outline of the Form of Government of the District of Columbia," by Major W. M. Black, Engineer Corps, U. S. A., and Acting Engineer Commissioner of the District; "The Washington Monument and the Library of Congress," by Mr. Bernard R. Green, Superintendent of Construction; "The Electric Railway System of Washington," by Mr. D. S. Carll, Chief Engineer; "The Washington Aqueduct System," by Col. A. M. Miller; "The Sewerage of Washington," by Mr. D. E. McComb, Superintendent of Sewers; "The Improvement of the District of Columbia," by Mr. Charles Moore, Secretary of the Park Commission.

On the morning of Wednesday the Members of the American Society of Civil Engineers were received by the President of the United States in the East Room of the White House. The reception, however, was the usual march-past and the perfunctory hand-shaking, which custom has so firmly established but which everyone knows should be abolished. No society or assemblage of such a size ought to accept such a sacrifice of valuable time and strength by the Chief Executive of the nation. A simple introduction to the President of the assembled members of the society by one of its officers, and a few words of welcome in reply on the part of President Roosevelt would have been much more satisfactory to the visitors and much less of a tax on the time and strength of our busy President.

At the business meeting of Wednesday morning, the reports of various committees were heard and disposed of by the convention. An able report was presented by the committee appointed to discuss the advisability of taking some action for the protection of engineers and the public from incompetent practitioners. The legal enactments and general practice of various nations were taken up in considerable detail, and the action taken for engineers was compared with what has been done for other professions. Special stress was laid upon the Illinois law of 1897, licensing architects, as many of the requirements of that law would apply to civil engineers; and good results had certainly followed the Illinois enactment in much reducing the list of pretenders and in greatly purifying architectural practice. The committee concluded, however, that as a national law applicable to civil engineers was impossible, and a uniform law among states was most improbable of enactment, owing to varied conflicting individual

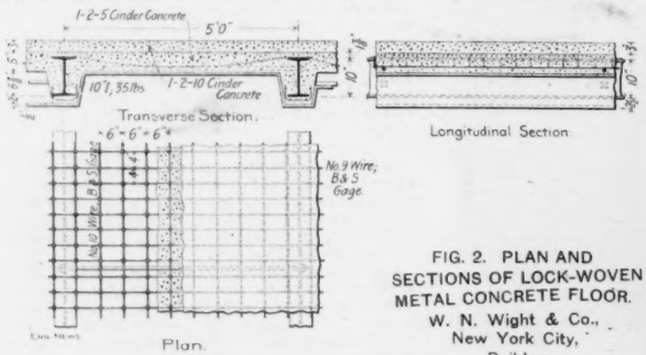


FIG. 2. PLAN AND SECTIONS OF LOCK-WOVEN METAL CONCRETE FLOOR. W. N. Wight & Co., New York City, Builders.

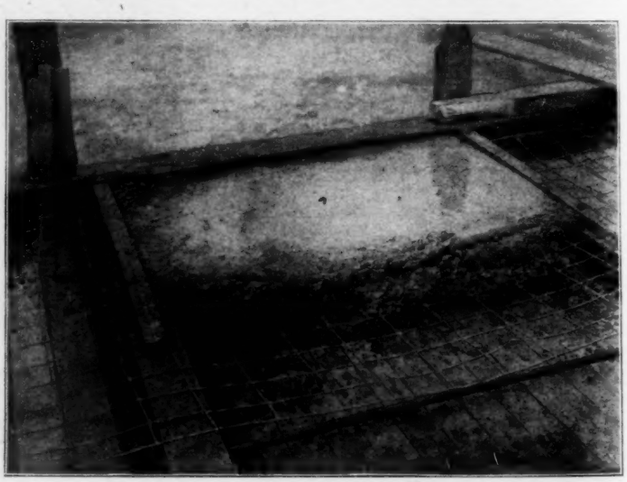


FIG. 3. VIEW OF LOCK-WOVEN METAL CONCRETE FLOOR UNDER CONSTRUCTION FOR TESTING.

interests, it was inexpedient for the society to take any action at this time, and the committee so recommended. This report was accepted and adopted by the convention. The committee reporting upon proposed amendments to the constitution, relating to admissions to membership, stated that the present method of permitting candidates to select the class for which they sought election was open to serious objection. The Board of Direction now had the right, under the constitution, to make this classification according to the record of the candidate; and the committee recommended an amendment permitting the issue of an unclassified "blue-list," or announcement of the names and claims of candidates for admission. This report was received and filed without discussion. An amendment was offered which had for its end the substitution of an open ballot for the present secret ballot. The form in which this amendment was offered aroused much discussion among the members present, and very considerable opposition to the change; the motion was finally tabled.

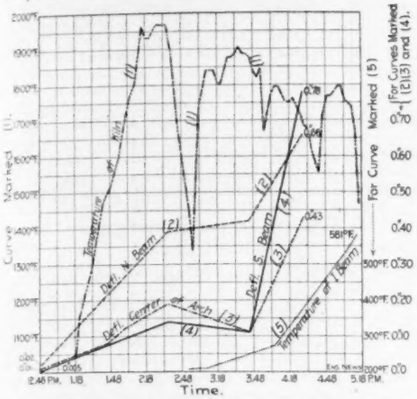


Fig. 4. Diagram Showing Range of Temperatures and Deflections During Test of Lock-Woven Metal Floor.

The report on time and place of holding the next annual convention was the subject of some curious evolutions. The Secretary reported that in response to the usual circulars of enquiry, St. Louis, Mo., was the point having the largest number of votes; but thanks to some vigorous individual effort, an overwhelming vote for Cleveland, O., had been forwarded to him at Washington. The motion was then made to adopt the latter city as the next place of meeting; but at this juncture a well-timed and persuasive speech, made to support an amendment suggested, practically stampeded the convention into showing a strong majority of those present as favoring Asheville, N. C., as the chosen spot. The whole matter was finally handed over to the Board of Direction, with power, but with the added clause that it was the sense of the present convention that Asheville should be chosen as the place and June, 1903, as the time of the next annual convention.

An excursion was made in the afternoon to the Washington Navy Yard, where the admirably equipped gun-shops were inspected, and a jacket for a 12-in. gun was shrunk in place in the presence of the engineers. The government towing-tank was also in operation, showing the method of testing the models of proposed warships. The evening of this day was devoted to a professional discussion of the following topics: Topic No. 1. "In contract work, either public or private, is it preferable to make separate contracts for the different branches of trades involved, or to combine all under one general contract?" The discussion opened by Geo. E. Gifford, M. Am. Soc. C. E. Topic No. 2. "Is it possible and desirable to keep accounts of work in progress in such a manner as to ascertain unit costs on each class of work?" The discussion opened by Samuel Whinery, M. Am. Soc. C. E. Topic No. 3. "Is steel susceptible of being made as permanent a building material as masonry?" The discussion opened by Charles G. Darrach, M. Am. Soc. C. E.

Thursday was entirely taken up by an exhibit of pontoon building by the U. S. Engineers at Washington Barracks, and by a steamer excursion to Fort Washington and to Mount Vernon. The interesting technical event of the day was the firing of a 10-in. army rifle mounted on a Crozier-Buffington disappearing gun-carriage, placed in a sunken concrete emplacement hidden in an innocent looking grassy hillside. At Mount Vernon, Mr. Herbert M. Wilson, of the U. S. Geological Survey, gave a short but most pleasing address on George Washington as a surveyor and civil engineer, proving that the Father of his Country was also one of the most able and far-seeing engineers of his time, and in a manner the father of the profession of civil engineering in the United States.

An informal dance at Willards, and a reception at the Corcoran Gallery of Art practically closed what was one of the very successful conventions of the society and certainly the best attended. The professional discussion of the topics following were somewhat interfered with by the necessity of using the same hall at Willards for social purposes: Topic No. 4. "In view of the numerous disasters caused by the contracting of channels, or the damming of small streams, should non-navigable streams be under the control of the National Government?" The discussion opened by Rudolph Hering, M. Am. Soc. C. E. Topic No. 5. "Should the National Government undertake the construction and operation of irrigation works?" The discussion opened by Elwood Mead, M. Am. Soc. C. E. Topic No. 6. "Should Engineering Practice be regulated by a code of ethics?" If so, how can such a code be established?" The discussion opened by Geo. A. Soper, Assoc. M. Am. Soc. C. E

FIRE TESTS OF FIREPROOF FLOORS BY THE NEW YORK BUILDING DEPARTMENT.

We illustrate in the accompanying cuts the construction of three new forms of fireproof floors, which have been submitted with successful results to the standard fire and water test of the Department of Buildings of New York city. In the New York Building Department test, as most of our readers know, the floor to be tested is built to cover the top of a rectangular brick-work hut or test house provided at the bottom with a grate and having the necessary doors, ash pit, smoke flues, etc., for the maintenance of a wood fire of high temperature. Fig. 1 is a transverse section of a standard test house covered with the Lock Woven Metal Concrete Floor made by W. N. Wight & Co., of New York city. The object of the test, as stated by the Building Department, is:

> To record the effect of the continuous heat of a wood fire below the floor system, averaging not less than 1,700° F. for not less than four hours, the filling between the two beams being loaded with a distributed load of 150 lbs. per sq. ft. of its area and all carried by such filling, the fire being extinguished at the end of the test with a stream of water directed against the bottom of the platform and discharged through a 1¼-in. nozzle under 60 lbs. pressure for five minutes, flooding the top of the platform with water under low pressure, and then again applying the stream of water through the nozzle under the 60 lbs. pressure to the bottom of the platform for five minutes.

The floors are built by the persons submitting them for testing, the work being observed by a representative of the Building Department. The test proper is conducted under the direction of the Engineer of Tests of the Department, who records the results and reports to the Superintendent of Buildings.

The three floors which we illustrate were tested on Feb. 4, May 2 and May 8, 1902. All three are constructed of concrete reinforced by an embedded structure of steel.

LOCK WOVEN METAL CONCRETE FLOOR.

This floor, illustrated by Figs. 1 to 5, inclusive, was submitted for testing by W. N. Wight & Co., of 102 W. 109th St., New York city. The area of the floor was 70 sq. ft., with a distance between bearings of I-beams of 14 ft., and a span of floor arch from c. to c. of beams of 5 ft. The time allowed for construction and drying was 28 days. The theory of the construction used was stated as follows:

> When galvanized steel wires, meshed in continuous sheets, are incorporated in the lower section of a high-grade Portland cement cinder concrete flat arch construction as a reinforcing element, spanning the distances between the upper flanges of standard I-beams, the beams being haunched and protected with similar concrete, the effect of the combination is to afford a suitable means of fire protection for the beams and space above, also for carrying the ordinary loads met with in common practice while subjected to a serious fire and water test.

TEST STRUCTURE, CONSTRUCTION AND APPARATUS.—The test house, shown in section by Fig. 1, was 14 × 14 ft. in plan and 10 ft high, internally; the roof being formed by the floor to be tested. This floor consisted of four 10-in., 35-lb. I-beams spaced 5 ft. apart c. to c., and having a span of 14 ft. in the clear. Over the tops of the I-beams, sheets of meshed galvanized wire were laid so as to have a sag between beams, as shown by Figs. 1, 2 and 3. The wire mesh used was the special "lock woven" fabric made by the builders of the floor. The concrete in which the wire netting and the beams were embedded was composed of one part Taylor's Portland cement, two parts sand and five parts steam ashes. The concrete filling, 3 ins. thick, was composed of one part Victor Portland cement, two parts sand and ten parts steam ashes. As will be seen from Fig. 1, three styles of ceiling construction were employed. The ceiling of the center bay consisted simply of a coat of King's browning plaster directly on the concrete; the left-hand side bay had a suspended ceiling of expanded metal and plaster, and the right-hand had a paneled ceiling made by haunching around the tie-rods with metal lath and plaster.

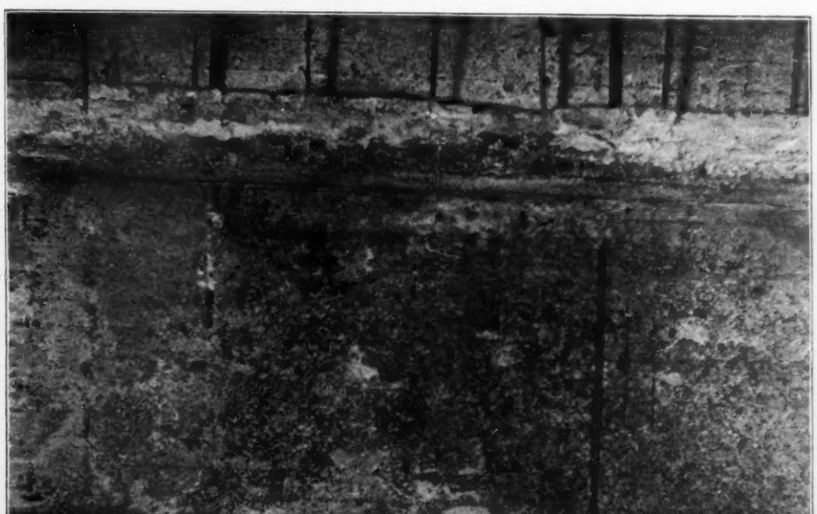


FIG. 5. VIEW OF UNDERSIDE OF LOCK-WOVEN METAL CONCRETE FLOOR AFTER FIRE AND WATER TEST.

The apparatus used in the test comprised a platinum-rhodium pyrometer for recording the temperature of the fire; a specially made thermometer (Celcius) which began to read 14 ins. from the bulb for recording the temperature of the south I-beam at a point next to the web on the top of the bottom flange; a Y-level for determin-

ing the deflections of the floor and beams, and fire pump, hose, etc.

RESULTS OF TEST.—The fire was started at 12.48 p. m.; water was applied to the ceiling at 5.18 p. m. for 5 mins., then to the roof for 6 mins., and then to the ceiling again for 5 mins., and the test discontinued at 5.37 p. m. The temperatures of the fire and of the south I-beam and the deflections of the I-beams and the floor at center are shown by the curves of the diagram Fig. 4. Fig. 5 is a photographic view showing the effect of the fire on the underside of the floor. An examination

TEST STRUCTURE, CONSTRUCTION AND APPARATUS.—The test house measured 14 × 14 ft. × 10 ft. high internally, the roof being formed by the floor system tested. The floor beams were 12-in., 31½-lb. I-beams spaced 6 ft. 1 in. apart c. to c., and having a clear span of 14 ft. As shown by Fig. 6, the metal element of the floor arch consists of 9-16-in. wrought-iron rods placed parallel 12 ins. apart, with their ends resting on the top of the bottom beam flange. At three points in the span these main rods are crossed by ½-in. wrought-iron tie-rods which are lashed to the

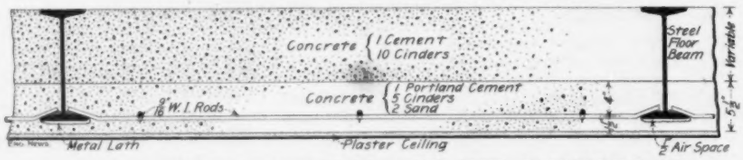


FIG. 6. SECTION OF WHITE CONCRETE-STEEL FIREPROOF FLOOR.
White Fireproof Construction Co., New York City, Builders.

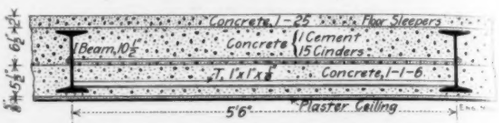


FIG. 7. SECTION OF AMERICAN CONCRETE-STEEL FIREPROOF FLOOR.
American Fireproof Construction Co., New York City, Builders.

of the test arches made two days after the test showed that the plaster applied to the ceiling was practically all destroyed by the fire and water. The suspended ceiling of the south bay was also destroyed, but the tie-rods were found in good condition. The tie-rod in the north bay east of the center was slightly distorted. The tie-rod east of the center in the middle bay was exposed almost its entire length, and about seven meshes of the metal fabric next to it were exposed. Otherwise the three arches were found in good condition. The deflections recorded were as follows:

	North Beam.	Center.	South Beam.
After cooling 150-lb. load on	0.195-in.	0.435-in.	0.11-in.
After unloading	0.18 "	0.425 "	0.09 "

In summarizing the results of the test, Mr. W. W. Ewing, Engineer of Tests, concluded that:

In consequence of the good record made by this floor during the various investigations, the various conditions of Section 106 of the Code having been fully met, I would respectfully recommend that the construction be allowed for use on spans up to 5 ft., with the usual allowable variable distance of 6 ins., when constructed as tested.

SUPPLEMENTARY WEIGHT TEST.—On Feb. 10 the floor was loaded with brick to 600 lbs. per

main rods at intersections with small wire. A 4-in. layer of concrete composed of one part Portland cement, two parts sand and five parts steam ashes embeds the metal. On this is placed a mixture of one part cement and ten parts steam ashes filled to the tops of the I-beams. The apparatus used was the same as described for the floor first tested.

RESULTS OF TEST.—The fire was started at 9.45 a. m., and the test discontinued at 3.09 p. m. At 10.54 a. m. the temperature was 1,112° F., from which time the heat gradually increased to 1,706° F. at 11.33 a. m., to 1,802° F. at 12.45 p. m., and to 1,904° F. at 1.21 p. m. With slight fluctuations the temperaure, then, remained between 1,900° F. and 1,976° F., until the end of the test. An examination of the arch after the test showed that the plaster applied to the ceiling was all destroyed by the fire and water, and that two of the 9-16-in. rods were exposed by the water; otherwise the floor was in good condition. As the result of this showing the engineer of tests made the same recommendation as was made in case of

by Figs. 7 and 8, the metal element of the [illegible] arches consisted of 1 × 1 × ⅛-in. wrought-[illegible] Tees placed parallel 12 ins. apart, with their [illegible] resting on the tops of the bottom flanges of [illegible] beams. These Tees were embedded in a 5½-[illegible] layer of concrete composed of one part Atlas and Dragon Portland cement, one part sand and six parts steam ashes. A filling composed of one part cement and 15 parts steam ashes was then carried to the tops of the floor beams, 6½ ins., and on top of this was placed a 2-in. mixture of one part cement and 25 parts ashes. The underside of the floor had a ⅝-in. coat of plaster. The apparatus used in the test was the same as for the floor first described.

RESULTS OF TEST.—The fire was started at 10.24 a. m., and the test was concluded at 2.49 p. m. The temperatures were, 1,292° F. at 10.33 a. m., and 1,517° F. at 10.39 a. m. From this time on the heat varied from 1,500° F. to 2,000° F., and was for the greater part of the time close to or above 1,900° F. An examination of the floor after the test showed that the ceiling plaster had all been destroyed, and that two of the T-bars in the center arch had their flanges exposed; otherwise the floor was in good condition. Based on these results the engineer of tests made the same recommendation as was made in the two tests previously described. The increase of the original load to 600 lbs. and its gradual removal gave the following deflections:

	Deflection—East beam, in.	Center of arch, in.	West beam. in.
Load, 150 lbs. per sq. ft.	0.10	0.025	0.125
" 300 " " "	0.125	0.05	0.10
" 450 " " "	0.175	0.075	0.175
" 600 " " "	0.20	0.125	0.175
" 600 " " "	0.175	0.20	0.175
" 450 " " "	0.125	0.175	0.20
" 300 " " "	0.15	0.10	0.175
" 150 " " "	0.075	0.125	0.15
No load	0.0	0.10	0.125

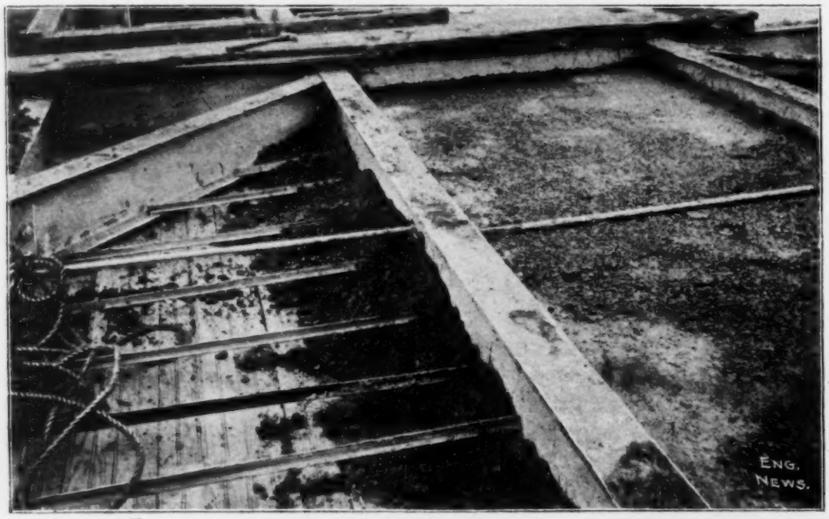


FIG. 8. VIEW OF AMERICAN FIREPROOF FLOOR UNDER CONSTRUCTION FOR TESTING.

sq. ft., and the load gradually removed. The deflections recorded were as follows:

Deflection:	Load, lbs. per sq. ft. 600	450	300	150	None
North beam, in.	0.195	0.165	0.141	0.082	0.034
South beam, in.	0.197	0.18	0.128	0.07	0.011
Center of arch, in.	0.12	0.107	0.092	0.07	0.035

WHITE FIREPROOF FLOOR.

This floor, illustrated by Fig. 6, was built by the White Fireproof Construction Co., 162-4 W. 27th St., New York city. The area of the floor tested was 85.17 sq. ft., with a distance between the bearings of the beams of 14 ft., and a span of 6 ft. 1 in. c. to c. between beams.

the floor just described. The increase of the 150-lb. load to 600 lbs., and then, the gradual removal of the load, showed the following record of deflections:

	Deflection—North beam, in.	Center of arch, in.	South beam. in.
Load, 150 lbs. per sq. ft.	0.09	0.08	0.03
" 300 " " "	0.08	0.18	0.08
" 450 " " "	0.19	0.305	0.13
" 600 " " "	0.17	0.455	0.20
" 600 " " "	0.17	0.505	0.22
" 450 " " "	0.10	0.505	0.17
" 300 " " "	0.07	0.465	0.08
" 150 " " "	0.05	0.35	0.09
No load	0.01(rise)	0.27	0.19

AMERICAN FIREPROOF FLOOR.

This floor was submitted for test by Mr. [illegible] Mertin, 33 Union Square, New York city, [illegible] American Fireproof Construction Co. Its [illegible] struction is shown by Figs. 7 and 8. The [illegible] of floor tested was 77 sq. ft.

TEST STRUCTURE, CONSTRUCTION [illegible] APPARATUS.—The test house measured [illegible] ft. × 10 ft. high, internally, with the floor [illegible] its roof. The floor beams were 10-in., 45 [illegible] beams of wrought iron, spaced 5½ ft. apart [illegible] c., and having a clear space of 14 ft. As s[illegible]

ANNUAL CONVENTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

The annual convention of this association was held in Cincinnati, O., May 20 to 22, the headquarters and place of meeting being at the Grand Hotel. The convention was largely attended and considerable interest was shown in the papers and discussions, in spite of the great heat, which made the meeting room very uncomfortable at times. Over 500 persons were registered, from 60 to 70% of these being "supply men" and guests. There were no special entertainments, and the only excusion made was a visit to the works of the Bullock Mfg. Co., the afternoon session on May 23 being adjourned at 4 o'clock for this purpose. Special excursions and entertainment were arranged, however, for the ladies of the party. There were numerous exhibits of lamps and electric appliances (no machinery), but these were for the most part scattered among the private rooms of the various exhibitors.

Two features of interest in the arrangements may be noted here. The first of these was the adoption of the plan of having certain "joint" papers composed of four or five short papers on the particular subject, presenting different opinions and points of view. The purpose of this was to bring out these different points of view before commencing the oral discussion, rather than to have simply the ideas of a single writer. Where the several authors

were present, each read his own contribution and the result was to start an animated discussion in most cases, as the members at large did not have to simply agree or disagree with one man when the subject was thrown open for discussion, but had had the matter presented to them from various standpoints.

The second feature referred to was the growth of the "question box" system, between 60 and 70 questions being on the list. In many cases written discussions on the subjects suggested had been sent in by members to whom the subjects had been assigned for this purpose, and care was taken to endeavor to get some one member to promise to answer each question when presented, in order to start the discussion. Of course, many of the questions were somewhat trivial, and many received little or no attention; but on the other hand some of them brought out very interesting remarks, and the general result seemed to be that this feature of the program may be almost as important as the more elaborate papers and reports. Unfortunately the number of questions was so great that interest could not be maintained and many of the subjects received but scant attention, even the written answers to the questions being listened to with indifference. There is no doubt that the program was entirely too long for the time available, and in future it would be well to submit the questions to a committee which would select as many of the most interesting or important as might reasonably be expected to be dealt with properly.

The first meeing was called to order about 10.30 a. m. May 20, when Gen. A. Hickenlooper, President of the Cincinnati Gas & Electric Co., delivered an address of welcome on behalf of the city, which was responded to by Mr. Frederic Nicholls.

The annual address was then read by the President, Mr. Henry Doherty (Denver Gas & Electric Co.), who devoted the greater part of the address to the work and development of the association, and the means by which its usefulness may be increased. He thought that members must take greater interest in its affairs and feel a greater responsibility for it; attention must not be confined simply to engineering or technical matters (important as these are), since they are taken up also by the various engineering societies, but the management and commercial side of the central station business must also receive most careful consideration. In most cases there is no good reason why one central station company should not supply all the current required in a town, and this is now done in many towns and cities where the gas and electric interests have been consolidated. Special attention needs to be given to the improvement of underground construction, to the relations between central station men and manufacturers, and the development of the markets for electric light and power. It was suggested that the smaller local associations should be asked to work in harmony with this association, and their officers invited to attend the conventions; also that professors at the various technical schools should be invited to attend, so that they have a better comprehension of the business side of electric light and power and the requirements of central station work, and thus be in a better position to give their students a training in this line as well as in theoretical and technical matters. The adoption of the metric system was approved. Another suggestion was to the effect that the President should not be expected to annually review the progress made in scientific and other matters, but that an "editor" should be appointed each year to undertake this work, since the President may often not be in a position to do it justice. The address was full of practical suggestions, and at its conclusion a resolution was passed providing for the appointment of a special committee to consider these suggestions, and arrange for carrying them into effect. This committee later reported in favor of adopting several of the plans, including the offer of a prize for the best paper on underground construction.

The public meeting then adjourned, and the association held an executive session.

DOES IT PAY TO CREOSOTE WOODEN POLES FOR ELECTRIC LINE WORK?

In the afternoon, the first paper presented was one on the above subject by Mr. W. E. Moore (Augusta, Ga.). An abstract of this paper is given elsewhere. The discussion turned largely on the proper methods of treatment and the proper quality or composition of creosote oil to be used, for information on which points members were referred to the practice of the Southern Pacific Ry., and to the report on metal ties and preservative treatment of timber (by E. E. R. Tratman, Associate Editor of Engineering News), which was published by the Bureau of Forestry, U. S. Department of Agriculture, in 1895. A "question box" subject bearing on this matter was then presented: "How may the butts of hard-pine poles be best preserved?" In answer to this, Mr. Doherty (Denver, Colo.), advised coating the poles with tar for 2 ft. above and 2 ft. below the ground line, as it is at this point that decay first occurs. The end of the butt should not be coated. If the tar is wet or green when the poles are being set, lime may be sprinkled over it to prevent its sticking to the hands and clothes of the men.

LAMP EFFICIENCY.

The next paper was on the following subject: "What Efficiency Lamp Should be Used, and How May This Efficiency be Determined for any Particular Station?" This was composed of contributions from Messrs. Henry L. Doherty, Samuel E. Doane, L. G. Van Ness, Francis W. Willcox, and Converse D. Marsh. The general proposition was stated by Mr. Doherty as follows:

The efficiency of the lamp (assuming that we are using as a standard a lamp of 16 c. p.) should be placed at that point where cost to the central station for the supply of current just balances the cost of lamp renewals; and when this point has been determined for a 16-c. p. lamp, then all the other-sized lamps should have an efficiency that would bring the cost of lamp renewals to the same point per kilowatt-hour consumed. In other words, when lamp renewals for any given efficiency lamp cost any more than it would cost the central station to supply additional current to yield the same amount of light from a lamp of lower efficiency, they should adopt this lower-efficiency lamp.

I do not think our rate of charges to the consumer should be considered at all except that we can afford to make a reduction in rate for the lower-efficiency lamps used. The only cost I see to the electric company in using lower-efficiency lamps would be boiler fuel and boiler-room labor, and costs incidental to a larger equipment. Boilers, engines dynamos, conductors and transformers would have to be increased and this would add additional costs for interest, taxes and depreciation on this increased investment.

The main point of the paper, or papers, was a consideration of the respective advantages and disadvantages of using lamps of 3.1, 3.5 and 4 watts per candle power, with their relation to rates, efficiency, life, regulation and other matters. Mr. Willcox and Mr. Marsh summarized their views as follows:

Francis W. Willcox (Harrison, N. J.). 1. The best available efficiency in central-station service for the 16-c. p. lamp is 3.1 watts per candle. Actually, the 2.75-watt lamp is the desirable one for average rates in use. 2. The 3.1-watt lamps can be used to advantage even when the voltage is kept 4% high, with fluctuations going still higher. 3. There should, therefore, be no central station which supplies current by meters using any lower efficiency than the 3.1-watt lamp in 16 c. p. 4. The best efficiency in smaller candle-power units is that which keeps the cost per K.-W.-hour renewals about the same as the 16 c. p. costs. This basis gives a 3.6-watts per candle efficiency, or better, for lamps of 8 and 10 c. p. 5. Very low candle-power units, being used chiefly for sign lighting, can be more liberally treated than the basis in par. 4 demands. An efficiency of 4 watts per candle is desirable for the 4 and 5-c. p. units, reducing this to 5 watts per candle for the 3 and 2-c. p. lamps, owing to the extreme fineness of filament in so small a unit.

Converse D. Marsh (New York, N. Y.).—The argument that low-efficiency lamps are preferable to high-efficiency lamps because finer regulation is required for the latter, is a double fallacy. The best possible regulation should be provided, regardless of lamp efficiency, if maximum satisfaction is to be afforded the consumer. Nothing is more irritating to a lamp user than variable intensity of light. Instead of using the delicacy of the high-efficiency lamp as a screen behind which to conceal slovenly management, let central-station men bring their regulation up to the highest practicable point, with a view to best satisfying their consumers; then it will not be necessary to waste energy on 4-watt lamps.

In the discussion, Mr. Ferguson endorsed the use of the 8-c. p. lamp, which Mr. Willcox thought would gradually replace the high-efficiency 16-c. p. lamps, and he also remarked that he is using 3.1-watt lamps with an alternating current system. The lamp manufacturer has paid so much attention to perfecting the 3.1-watt lamp that he does not make 3.5 or 4-watt lamps as good in proportion. On the other hand, Mr. Doherty claimed that with the voltage raised, as it should be, the average life of a 3.1-watt lamp is rarely over 300 hours, or considerably lower than the life usually claimed. A long discussion followed as to the economy of high and low-efficiency lamps, the respective advocates working out their calculations on a blackboard under a running fire of comment and dissent. Neither side appeared to convince the other or the members in general, and eventually the discussion was cut short, as it threatened to consume the entire time of the convention.

At the evening session the first paper presented was one by Mr. Irvin Butterworth on

CARING FOR CONSUMERS' COMPLAINTS.

This discussed the general policy to be observed in dealing with such complaints and described the practice of the Denver Gas & Electric Co., some particulars of which we give below, as the system is applicable to other kinds of work.

All complains received at the office (personally or by telephone or mail) are referred at once to our order clerk, who enters them in a large book so ruled as to show the reference number of the complaint and date and hour of its receipt, the name and address of complainant, the character of the complaint, the name of the employee sent to remedy it, the time such employee is sent, the time the complaint is reported as remedied and the work done in remedying it. An order is then immediately filled out, corresponding to the entries in the book, and turned over to the shop force for prompt attention. In urgent cases the complaint is telephoned to the shop for immediate attention, followed by a confirming order. When the workman has attended to and remedied the complaint, and while he is still at the premises of the complainant, he fills out the remaining blanks on the order, showing the cause of the trouble, his method of remedying same, the date and his own name, and secures the signature of the complainant (or of a responsible member of his family), certifying that satisfactory attention has been given. The order is then returned to the order clerk, who enters the facts on his record book, above described. He then fills out and mails to the complainant a return postal card, worded as follows: "On ....., 1902, you reported ..... Kindly fill out this return postal card stating whether the matter has been attended to to your entire satisfaction. Your prompt reply will be greatly appreciated. Very truly yours, The Denver Gas & Electric Co."

The reference number is put on each of these cards before sending them out, in order that responses not signed may be identified, and those that are returned are checked off on the record book. Of course, many of the cards are not returned, but many of them are; and most of these report the trouble to have been satisfactorily remedied. Occasionally one comes back with the statement that the trouble still exists or has not been satisfactorily attended to. In such cases a second order is made out and sent to the shop for immediate attention, with proper caution to the workman taking the order. The returned postal card is then attached to the original order, and after the second order comes back with the notation that the trouble has been remedied, the workman that attended to the original one is called upon by the order clerk to explain his failure to have properly remedied the trouble.

CHANGES IN THE PLAN OF UNIFORM ACCOUNTING.

The next paper was by Mr. J. P. Crowley (St. Paul, Minn.), and suggested certain changes in the plan of uniform accounting presented at the last convention. The general classification in that plan was made with the idea of harmonizing it with the system adopted for street railway accounting, on the assumption that the present tendency is towards a consolidation of electric railway and lighting interests. Mr. Crowley thought the tendency was rather towards a consolidation of gas and electric lighting interests, and that there should be greater similarity of accounting methods for these two latter industries.

LOOSE-LEAF AND CARD-INDEX LEDGERS AND METER RECORDS.

This paper consisted of contributions from Messrs. G. E. Tripp, H. H. Fairbanks, G. W. Davenport and C. R. Price. The paper was of interest in showing the development of the card index system in keeping accounts with the patrons of an electric lighting company.

The rest of the evening was devoted to the "question box."

THREE-PHASE VS. TWO-PHASE FOR CITY DISTRIBUTION.

On Wednesday two papers were presented on this subject. The first was by Mr. B. A. Behrend (of Cincinnati). The conclusion which he reached was that there is comparatively little choice between the two systems of distribution, but that there are certain slight advantages in favor of the three-phase system. If 75% of the load is a lighting load and 25% is a load that requires little attention to regulation (such as an arc-light load having its own regulator, or a motor load), a three-phase generator has the advantage that it can be operated as a single-phase machine, the lighting load being connected between two outside wires. In this case the lighting load can be very easily regulated, while the arc-light or motor load takes care of itself. A much larger paper was then read by Mr. Charles F. Scott (of Pittsburg), discussing in some detail the relations between the various machines and appliances as built for the two systems. He compared the one, two and three-phase systems to one, two and three-crank engines. His conclusions were practically the same as those arrived at by Mr. Behrend, to the effect that there is really little to choose between the two-phase and three-phase systems.

A discussion on standard rules for electrical construction and operation was then taken up, and turned mainly on a point brought up by Mr. Brophy (Boston), namely, what means should be taken to prevent the enforcement of the new rule of the National Underwriters' Association requiring higher insurance for buildings which are within 75 ft. from a wire carrying 4,000 volts. No conclusion was arrived at. The greater part of the time of the session was again taken up by the "question box," but the number of questions and the oppressive heat were not conducive to maintaining interest in the proceedings, and the discussion flagged.

In the afternoon there was an executive session, after which was presented a joint paper by several authors on "The Protection of Long Distance Transmission Lines," and of this we shall give an abstract later. The meeting adjourned at 4 p. m. to take a special train to the works of the Bullock Mfg. Co., where refreshments were served. In the evening there was another executive session, lasting until nearly 9 p. m., followed by a public session, which adjourned about 9.30 to enable the members to attend an entertainment at the Itannicnic Club. At the public session two papers on the use of electricity for decorative lighting were read.

The Thursday morning session opened with a "question box" discussion on several points relating to the use of the new Nernst lamp, and this was followed by a brief report from the Committee on Standard Candle-Power of Incandescent Lamps. Mr. Frank A. Wolf, Jr., representing the National Bureau of Standards, then gave a brief address on the work and purposes of the Bureau, and the buildings and equipment for the permanent headquarters of the Bureau at Washington. A paper on

PERFORMANCE OF 220-VOLT LAMPS

was read by Mr. F. W. C. Bailey, showing the results of photometric tests of selected lamps from different makers. These tests were undertaken as a result of Mr. Bailey's doubts as to the accuracy of certain beautiful curves sent him by makers in reply to a request for accurate data on the performance of their high-voltage lamps. The tests indicate that the lamps on the market fall far below the assumed efficiency.

RATES.

The next subject was a joint paper on the question of rates to be charged for electric current, the several authors being Messrs. Henry L. Doherty, L. R. Wallis, R. J.

Patterson, Samuel Scovil, E. F. Phillips, Alex. Dow and Louis A. Ferguson. The views and opinions expressed by these various writers were all at variance one with another, and the discussion, which occupied a good share of both the morning and afternoon sessions, rivaled that on "Lamp Efficiency" (already noted) in length and energy. The discussion turned largely on whether the rate-making system should be based on the principle of a uniform rate for average conditions (as in gas lighting and electric railway rates), or upon that of making each consumer pay as nearly as possible his own proper share of the expenses of the company. From the various systems used and proposed we give two, used in Denver and Chicago:

DENVER (Henry L. Doherty).—Every consumer must contract to pay us $12, plus $6 for each meter more than one, plus $1.80 per lamp connected, plus 5 cts. per kilowatt for current. From these prices we allow a discount of 50% and 10%.

CHICAGO (Louis A. Ferguson).—The Wright demand system, as employed in Brighton, England, while admirably adapted to the customs of the English people and the conditions surrounding a municipal corporation, was considered unsuited to the commercial methods prevailing in this country, and it was decided that the system should be Americanized.

To fill the requirements of American conditions, the writer suggested the method of basing each monthly bill upon the customer's actual maximum in that month, and to charge the full rate of 20 cts. per kilowatt-hour during each of the six winter months for all electricity consumed monthly until the consumption reached the equivalent of 45 hours' use of the maximum number of lamps lighted simultaneously, as indicated by the Wright demand meter, and to charge 10 cts. per kilowatt-hour for all electricity consumed in excess of that amount.

During the six summer months, however, the full rate was charged for all consumption until it reached the equivalent of 15 hours' use of the maximum number of lamps lighted simultaneously, and for all electricity in excess of that amount the rate of charge was 10 cts. per kilowatt-hour.

We have within the last year simplified our method of charging by abandoning the difference between the summer and winter rates. We now charge the full rate of 20 cts. per kilowatt-hour for the equivalent of one hours' daily use of the maximum demand throughout the year, our reason for the change being that we found it objectionable to increase the rate of charge by the increase of hours in the fall months, just at the time when the consumer was beginning to use a larger quantity of electricity.

We have in use in Chicago at the present time a total of 13,022 Wright demand meters and 15,633 recording meters, the income from the customers using Wright demand meters being $986,560 for the fiscal year ending March 31, 1902. The average discount from the list is 35.1% for light and 49.1% for power. Of the Wright demand meters 94% are 25 amperes and under, showing that the bulk of our business on this system is with relatively small customers.

The total number of customers on our books is 18,623, of which 61.7% are on the Wright demand system. On March 31 we had 2,737 power customers, of which 50.7% were on the Wright demand system. The total investment in meters of all kinds on the company's system is $353,000, of which 23% is for Wright demand meters. The load factor for the Chicago companies for the last fiscal year was 27.1%, showing an actual daily use of the system's maximum of 6½ hours.

The total yearly expense per recording meter in 1897, including the salaries of superintendent, bookkeeper, inspectors and helpers, miscellaneous supplies, repairs and renewals (before we adopted the Wright demand system of charging) was $2.95 per recording meter. In the year 1901 the total yearly maintenance expense per recording meter, including the same items, was only $1.85 per recording meter, showing that the cost of maintaining Wright demand meters is inconsequential.

HOT WATER AND STEAM HEATING.

The last subject taken up was another joint paper, by Messrs. D. F. McGee, C. R. Maunsell, P. H. Korst and J. F. Porter. We shall give an abstract of this later.

The usual resolutions of thanks to the entertainment committee, etc., were then passed.

The following papers were presented by title only, owing to lack of time for their consideration: "Advantages of Gas Engines for Central Station Work," by Charles H. Williams; "Oil Fuel for Boilers," by Jas. W. Warren and H. T. Edgar; "What Improvement is Desired in Meters," by Robert Ferris and C. A. White; "Are Free Lamp Renewals Desirable?" by James English, F. Ellwood Smith, F. W. Little and W. J. Greene.

OFFICERS.

Officers for the ensuing year were elected as follows: President, Louis A. Ferguson (Manager of the Chicago Edison Co.), Chicago; Vice-Presidents, C. L. Edgar, Boston, and E. H. Davis, Williamsport, Pa.; Secretary and Treasurer, James B. Cahoon, New York, N. Y.

The association voted to hold its next meeting at Chicago in 1903, and at St. Louis in 1904.

A LADLE CAR FOR HANDLING MOLTEN SLAG.

We illustrate herewith a large ladle car especially designed for carrying molten slag from the blast furnace to a dump. Small size ladles have been running on narrow gage tracks have generally been used for this work, but are expensive to keep in repair and the slag when handled in small portions is apt to chill while being moved before it can be dumped. The car shown in the illustration is designed to carry 16 tons of molten slag (200 cu. ft. It has been especially designed for this work by its manufacturers, M. H. Treadwell & Co., of 95 Liberty St., New York city, and embodies some novel features in mechanical design.

On many of the cinder cars in common use the frame which supports the ladle forms the only connection between the front and rear trucks and has to take all the pulling and buffing strains which occur in hauling a train of such cars over the steep grades, rough tracks of the slag dump. In the present car, it will be seen that a heavy under-frame connects the front and rear trucks,

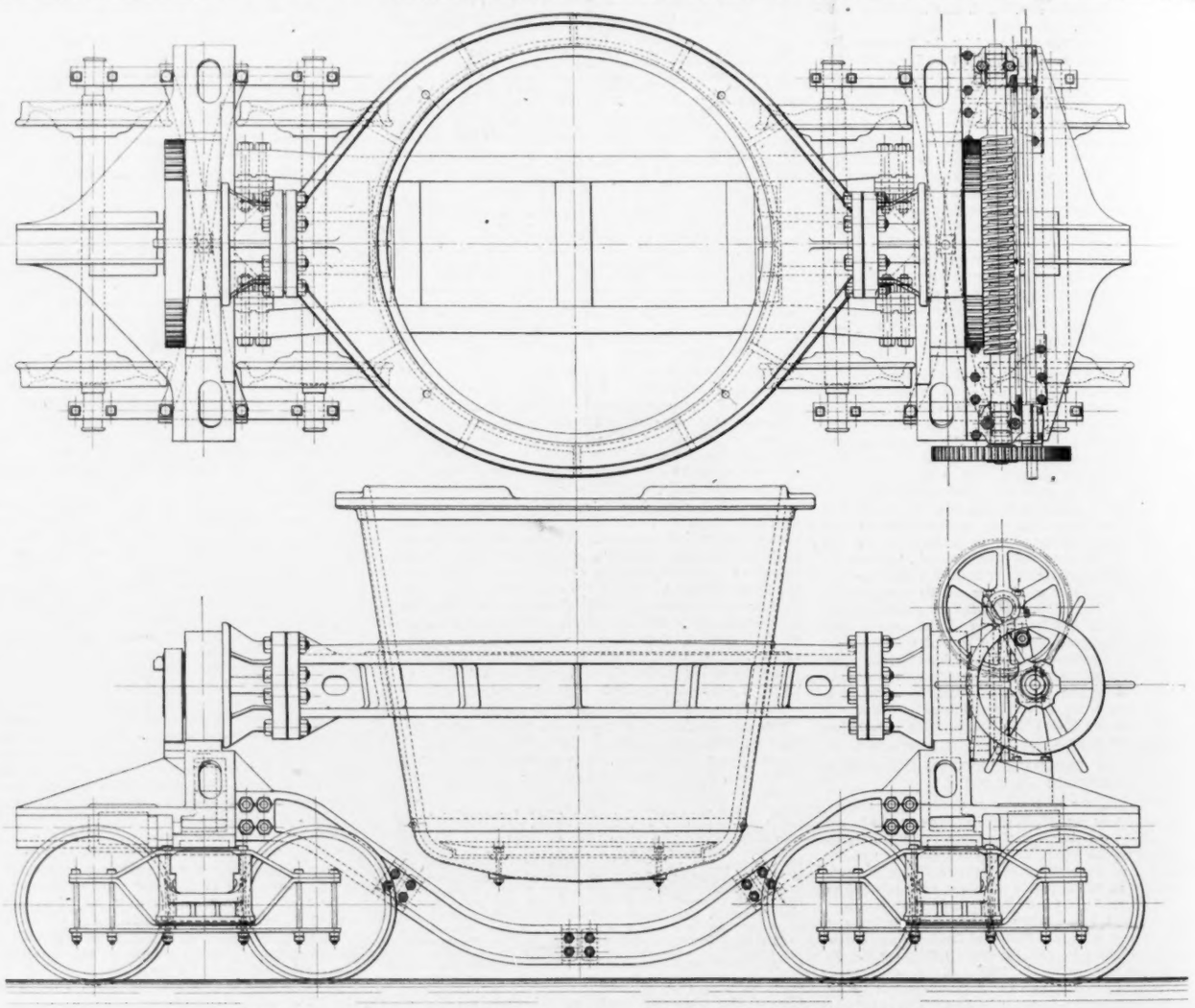


FIG. 1. PLAN AND ELEVATION OF LADLE-CAR OF 16 TONS' CAPACITY FOR CARRYING MOLTEN SLAG.
M. H. Treadwell & Co., 95 Liberty St., New York City, Builders.

and the ladle supports and gearing have to sustain only dead weight.

The safe support and tipping of the ladles involves some rather difficult problems. It is desirable that the ladle shall be normally carried centrally on the car, and also that when tipped to discharge its contents, it shall pour the slag as far to one side of the track as possible. Further

the gearing must be as direct and simple as possible, avoiding every chance of breakdown or delay. The accompanying illustration will make it clear how the problem has been solved.

The ladle frame has a cylindrical trunnion at each end which can roll to one side or the other on a flat trackway running crosswise of the car. To make this rolling true and insure against slip, a pinion at each end concentric with the trunnion engages a rack beside the flat trackway. To enable the ladle frame to be rolled either way and the ladle to be tipped, a worm-wheel is made fast on the shaft of the ladle-frame and a worm engages with the top of this wheel. The worm is revolved by the hand-wheel seen in the cuts through the medium of speed reducing gearing. The ladle is so balanced in its frame that one man can tip and discharge its contents in two minutes.

The trucks of this car are built with standard M. C. B. wheels, axles, journal boxes, brasses, truck bolsters and automatic couplers, which greatly facilitates repairs. All parts of the car are also made interchangeable. Steel castings are used for the gearing frames, under-framing connecting the trucks, and the truck bolsters. The worm is of wrought iron and the gear wheels are cut. The fact that the empty car weighs 60,000 lbs. gives an idea of its very solid and substantial construction.

The manufacturers inform us that five of these cars are now in use at the works of the National Steel Co., Youngstown, O., and additional cars have been ordered.

EXPERIMENTS AT WORCESTER, MASS., ON TREATING ACID IRON SEWAGE IN A CLOSED SEPTIC TANK.*

By Leonard P. Kinnicutt† and Harrison P. Eddy.‡

The general action of a septic tank on crude sewage is now comparatively well understood. It is the breaking down of complex organic compounds, such as proteids, carbohydrates, fats, into simpler substances and thus preparing the sewage to be more easily purified by the double contact method or continuous filtration. The changes that take place in the septic tank and the amount of organic matter that has been removed from the sewage have usually been determined by examination of the crude sewage and effluent alone. The study of the gas evolved and of the deposit formed are, however, of very decided importance, for the only way organic matter can be removed from the sewage is by precipitation or by being changed into gas; and the determination of the amount and of the composition of the gas formed give a much better idea of the energy of the bacterial action than can be obtained by the examination of the sewage and the effluent. The effluent from a septic tank is usually considered as the sewage from which a certain amount of organic matter has been removed, while, in fact, it is the sewage minus this quantity but with the addition of liquid compounds derived from the decomposition of the sludge at the bottom of the tank and of suspended matter thrown up to the surface of the liquid by violent evolutions of gas.

In our study of the action of the septic tank on iron acid sewage we have, therefore, not only examined the sewage and effluent as to the amount of solid matter and nitrogen in the form of free and albuminoid ammonia they contain, but have also studied and examined the deposit and crust formed in the tank, have made careful and continuous measurements of the amount of gas evolved, and studied its composition.

The experiments on the action of the closed septic tank on Worcester sewage were begun in the autumn of 1900, and have been continued without interruption. In the months of January, February and March, owing to the changes in the sewerage system of Worcester, the character of the sewage was very variable, and at one time in January the amount of free acid in the sewage in the septic tank was so great that it may have acted as a sterilizing agent. Half-hour samples of the sewage and effluent have been taken day and night, mixed and sterilized at the end of the day, and at the conclusion of a week aliquot portions of the 24-hour samples have been thoroughly mixed and the resultant mixture analyzed.

The amount of ghs given off each day has been noted and samples of the gas have been taken, often daily and always weekly, except during the months of January, February and August, for analyses. The amount of deposit formed has been measured, and its composition as well as the composition of the crust determined. The maximum and minimum daily temperature has been recorded and the temperature of the sewage and effluent have been taken twice daily, at 9 a. m. and at 5 p. m.

The septic tank used in these experiments was a discarded iron pressure tank, 14 ft. long and 5 ft. in diameter. The inlet tube was 2½ ins. in diameter and bent at a right angle after it entered the tank and extended down to about 1 ft. below the level of the surface of the sewage. The outlet tube, of the same diameter, at the opposite end of the tank, also extended about 1 ft. below the level of the sewage. At the top of the tank, near the forward end, was a manhole, large enough to allow one to enter the tank; at the other end a smaller opening, large enough to allow the entrance of a 2-in. glass tube for the purpose of measuring the depth of the sludge. Both of these openings were closed with air-tight covers. On the top of the tank, near the center, was also a gas outlet pipe connected with a T-tube. One end of the T-tube was joined to a standard gas meter, the other end with a pipe for collecting samples of gas for analysis. Both ends of the T were fitted with brass stop-cocks.

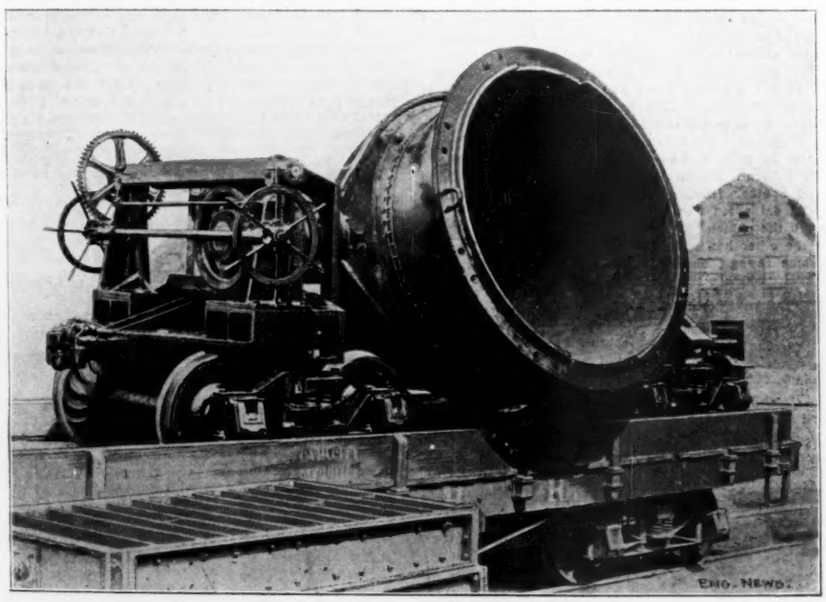


FIG. 2. VIEW OF 16-TON LADLE-CAR, SHOWING LADLE TIPPED.

The sewage, before it entered the tank, was passed through a screen chamber, the meshes of the screen being ½-in. apart; and the effluent, as it passed from the tank, flowed through a deep wooden effluent box.

The sewage level in the tank was 4 ft. from the bottom, which gave a volume of 1,762 U. S. gallons, and the flow, which was continuous, was so regulated that the time of passage through the tank was 18 hours. The tank was buried so that only the top surface was on the level of the ground, and it was covered in winter with a rough shed, for convenience in taking observations and collecting samples.

WORCESTER SEWAGE.—The sewage used in the experiments was Worcester sewage as it reaches the chemical precipitation plant at Quinsigamond.

The average amount of free and albuminoid ammonia, as given by weekly analyses from October, 1900, to January, 1902, is shown in Table III.

The amount of free acid and iron salts it contains varies, but the following is the mean of analyses made last summer on samples composed of samples taken every half-hour day and night for seven consecutive days, and gives a good idea of its general composition:

(Parts in 100,000.)

Total solid matter	74.20
Suspended substances	16.50
Substances in solution	57.70
Iron, Fe, in solution	5.78
Aluminum, Al, in solution	0.07
Ammonium, NH_4, in solution (occurring as free ammonia)	1.18
Sulphur trioxide, SO_3, in solution	19.56

These amounts give on calculation for substances in solution:

Ferrous sulphate $FeSO_4$	15.77
Aluminum sulphate, $Al_2(SO_4)_3$	0.44
Ammonium sulphate $(NH_4)_2SO_4$	4.33
Free sulphuric acid, H_2SO_4	10.32

The analyses also gave:

Iron, Fe, in suspension	3.51
Aluminum, Al, in suspension	0.15
Sulphur, S, in suspension	0.09

The form in which the iron in suspension in the sewage occurs we have not as yet determined; probably it is united to organic matter.

The essential difference between Worcester sewage and the sewage of most cities is in the amount of copperas and free acid it contains, and the conclusions to be drawn from our experiments apply only to sewage of this character.

THE ACTION OF THE SEPTIC TANK ON THE SOLID MATTERS IN THE SEWAGE.

As one of the most important effects of a septic tank is the removal of solid matter from the sewage, it is surprising to see, in reviewing the literature of the subject, how little data can be found; and what is given rests, as a rule, on comparatively few analyses.

Dibden* gives the results of 13 analyses on samples collected at Exeter, England.

Fowler† in his examination of the septic tank at Manchester, England, made two sets of experiments on the amount of suspended matter found in the sewage and the effluent. One set of 39 samples represented the sewage and effluent from Oct. 2 to 31, 1900, the other set of 36 samples represented the sewage and effluent from Nov. 14 to Jan. 24, 1901. Mr. Fowler also determined the amount of soluble solids in six samples of sewage and effluent, stating that the results obtained have been confirmed by similar observations.

Mr. Harrison‡ in his article on purification of sewage at Leeds, England, gives the average of all his analyses of sewage and tank effluent, made with the closed septic tank installation, not stating, however, the number of analyses.§

The Massachusetts State Board of Health at Lawrence has for the last three years experimented with the closed septic tank. The reports, however, give no data regarding the removal of solid matter from crude sewage by the action of the tank, though in their report of 1900 data are given as to the amount of solid matter removed by septic action on sewage sludge.

At Worcester we have made a set of experiments extending from October, 1900, to January, 1902. For 15 months half-hour samples have been taken daily, and at the end of a week a sample of these half-hour collections, made up in the way previously described, has been analyzed. The accompanying table gives the result of these analyses, also the average temperature of sewage and effluent, together with the average daily amount of gas given off from a tank.

The average amount of total solid matter entering the tank during the 15 months, October, 1900, to January, 1902, equalled 74.00 parts in 100,000, while the average amount in the effluent was 58.00 parts, a difference of 22.25%.

The amount of total solid matter, both in the sewage and effluent, varied greatly, and there seems, according to the tabulated results given, to be no direct relationship between the amount removed, calculated in percentages, and the amount contained in the sewage; nor does the table show that the amount removed depends directly on the temperature; nor does there appear to be any direct ratio between the amount of gas evolved and the amount of solid matter arrested in the tank.

The substances in solution in the sewage averaged 50.54

*Slightly condensed from the Third Report of the Connecticut Sewerage Commission, R. A. Cairns, Secretary, Waterbury, Conn.

†Professor of Chemistry, Polytechnic Institute, Worcester, Mass.

‡Superintendent of Sewers, Worcester, Mass.

*Purification of Sewage and Water. Sanitary Publishing Co. London, 1897, p. 76.

†City of Manchester. Rivers Department. Annual Report. March 27, 1901, pp. 33-4.

‡Journal Soc. Chem. Industry, 1900, p. 512.

§Detailed summaries of the results at Exeter, Manchester and Leeds are given by Messrs. Kinnicutt and Eddy.—Ed.

parts per 100,000, in the effluent 40.09, showing that 20.67% had been removed. The amount of suspended matter in the sewage was 24.06 parts per 100,000, of which 25.57% were arrested by the passage of the sewage through the tank.

The percentage of suspended matter arrested does not seem to depend directly on the amount of suspended matter in the sewage, but does seem to be affected by the temperature, for in the cold months, November to March, 43.95% was seemingly removed, while in the warmer months, April to November, the amount was only 9.21%.

This result was unexpected, and may be accidental, and we do not think too much consideration should be paid to it unless it is confirmed by another year's work. That less suspended matter is removed in the warmer months can, however, be easily explained by the fact that a very much larger amount of gas is evolved during the warm than during the cold months, and consequently there is much greater disturbance of the sludge at the bottom of the tank, so that the liquid in the tank contains a larger amount of suspended matter.

That the amount of total solid matter, and of the suspended matter, removed from the sewage varies greatly from month to month, is, we think, clearly shown by the results we have obtained, and they indicate that no correct opinion as to the amount of solids removed from the sewage can be obtained by analyses which extend only over a small portion of the year.

If the results obtained at Worcester are compared with those obtained at Exeter, Manchester and Leeds we obtain the following table:

Per Cent. Removed.

	Total.	Soluble.	Suspended.
Worcester	22.25	20.67	25.57
Exeter	23.81	— 2.576	56.01
Manchester	27.22	15.45	57.06
Leeds	34.61	12.05	70 37

The most striking difference between the results obtained at Worcester and those obtained at the places noted is in the percentages of soluble and suspended solids removed; the per cent. of soluble matter removed at Worcester being much greater; while the per cent. of suspended matter is only about half as large as that removed at Manchester or Exeter, and only about one-third of the amount removed by the septic tank at Leeds.

This difference can be explained by the character of Worcester sewage, containing, as it does, large amounts of iron sulphate. It is often assumed that the difference in the amount of total solids in the sewage and in the effluent is due to liquefaction and decomposition of the suspended matter. This, as we have previously stated, is far from being the case. Changes take place both with the soluble and the suspended matter and the amount of solid matter removed is the resultant of these two actions. There is no question in most cases that some of the soluble solids are rendered insoluble by septic action and some of the solid matter in solution is decomposed with the formation of gas. The amount of soluble matter thus acted upon varies, not only with the character of the sewage, but undoubtedly is also more or less dependent on the temperature. In the three cases cited, Exeter, Manchester and Leeds, Exeter is the only one where the solids in solution are not greatly reduced by the sewage passing through the septic tank.

The changes that take place as regards the soluble substances in Worcester sewage have been partially determined. The total amount of iron, and the iron in solution, were determined in a number of weekly samples of sewage and effluent. The results showed that there was always a large amount of iron removed from the sewage, the amount ranging between 25% and 50%, and that the amount of iron in solution in the effluent was always much less than the amount in solution in the sewage.

The following two analyses give the maximum and minimum results obtained both as to the amount of iron removed and the amount of iron in solution in the effluent.

	1.			2.		
Iron.	Sewage.	Effluent.	Removed, %.	Sewage.	Effluent.	Removed %.
In solution	4.19	0.084	98.22	7.28	3.19	56.18
In suspension	2.70	3.681	— 36.34	2.98	5.22	— 75.16
Total	6.89	3.765	45.36	10.26	9.41	18.03

The iron in solution both in the sewage and in the effluent was practically all in the form of sulphate, while the iron in suspension in the sewage was not united to sulphur, as the suspended matter did not, as a rule, contain sulphur, and never in greater amounts than 0.1%. On the other hand, the iron in suspension in the effluent was practically all in the form of sulphide.

The amount of iron sulphide in suspension in the effluent is very variable, for the iron sulphide in the finely divided state in which it occurs in the tank settles slowly, and even after having once settled down to the bottom of the tank is easily brought again to the surface by the gas which rises from the decomposition of the organic matter at the bottom of the tank, and in the summer months, when active bacterial action is taking place in the sludge, and large masses of solid matter are continually being brought to the surface, the effluent will contain more iron sulphide in suspension than in the colder months.

TABLE I.—Analytical Results Obtained by Experimental Closed Septic Tank at Worcester, Mass. (Parts per 100,000.)

Month. 1900.	Mean temperature F. Sewage.	Mean temperature F. Effluent.	Gas, cu. ft. per day.	Total solids. Sewage.	Total solids. Effluent.	Total solids. Removed. Parts.	Total solids. Removed. Per cent.	Solids in solution. Sewage.	Solids in solution. Effluent.	Solids in solution. Removed. Parts	Solids in solution. Removed. Per cent.	Solids in suspension. Sewage.	Solids in suspension. Effluent.	Solids in suspension. Removed. Parts.
October	67.1	65.4	9.15	72.05	52.75	19 30	26.79	49.55	36.75	12.80	25.83	22.50	16.00	6.50
November	61.9	57.8	6.43	70.24	52.12	18.12	25.80	46.08	37.08	9.00	19.53	24.16	15.04	9.12
December	52.6	51.0	2.95	54.95	46.80	8.15	14.84	39.05	35.90	3.15	8.067	15.90	10.90	5.00
Jan'y, 1901.	51.5	51.4	0.59	78.80	69.80	9.00	11.42	57.13	58.53	— 1.40	— 2.45	21.67	11.27	10.40
February	50.0	....	0.69	68.85	46.30	22.55	32.75	44.30	38.10	6.20	14.00	24.55	8.20	16.35
March	48.5	48.0	0.50	86.60	58.00	28.60	32.33	54.80	45.33	9.47	17.28	31.80	13.27	18.53
April	49.0	48.0	0.80	57.40	47.60	9.80	17.07	40.52	37.00	3.52	8.68	16.88	10.60	6.28
May	54.8	54.7	2.89	59.73	47.20	12.53	20.97	44.40	33.47	10.93	24.61	15.33	13.73	1.60
June	59.2	60.0	8.12	76.15	65.10	11.05	14.51	53.35	39.10	14.25	26.71	22.80	26.00 —	3.20 —
July	72.6	72.5	24.21	82.10	59.50	22.60	27.53	57.10	41.45	15.65	27.41	25.00	18.05	6.95
August	75.1	75.0	14.55	85.76	65.68	20.08	23.41	63.88	46.76	17.12	26.80	21.88	18.92	2.96
September	68.0	67.8	13.08	83.90	63.65	20.25	24.13	62.80	41.25	21.55	34.31	21.10	22.40 —	1.30 —
October	64.0	62.8	12.17	91.06	66.86	24.20	26.58	56.80	38.06	18.74	32.99	34.26	28.80	5.46
November	56.1	54.1	11.65	85.88	68.36	17.52	20.40	47.84	38.80	9.04	18.47	38.04	29.56	8.48
December	48.15	49.3	1.672	65.55	59.70	5.85	8.928	40.50	33.80	6.70	16.54	25.05	25.90 —	0.85 —
Mean	58.57	58.41	7.28	74.60	58.00	16.60	22.25	50.54	40.09	10.45	20.67	24.06	17.90	6.15
Grains, pr gal.	....	....	.....	(43.69	33.97	9.72)	.....	(29.60	23.48	6.12)	.....	(14.09	10.48	3.61)

Similar results must be expected whenever acid sewage containing iron sulphate in solution undergoes septic action, and with such sewage a larger amount of undecomposable sludge must be formed than with domestic sewage. The effluent from such a sewage will contain more or less iron sulphide and the occurrence of this salt in the effluent must have an effect on the action of bacterial beds, not only in causing more or less clogging of the beds, but also on account of the changes that iron sulphide undergoes when the surface of the bed becomes dry, i. e., forming ferric oxide and free sulphur.

Mr. Fowler, of Manchester, has also made determinations as to the amount of iron in solution and in suspension in crude sewage and in the effluent from the septic tank. His experiments, like ours, show that iron is removed from the sewage, and in variable amounts, by the passage of the sewage through the septic tank. In Manchester sewage, however, most of the iron is in the form of an insoluble salt, and the removal of the iron is due to the subsidence of this suspended substance, and not, as with Worcester sewage, due to the formation of an insoluble iron salt. Mr. Fowler's results also indicate that part of the suspended iron salts in Manchester sewage are rendered soluble by the action of the tank. If this takes place in Worcester sewage, it is masked by the reverse reaction.

ACTION OF THE SEPTIC TANK ON THE ORGANIC MATTER IN THE SEWAGE.

FREE AMMONIA.—In the decomposition of organic nitrogenous products by bacteria, ammonia, carbon-dioxide, water, marsh gas, hydrogen, and probably free nitrogen are given off. The greater part of the ammonia and a portion of the carbon-dioxide remain in the solution and are found in the effluent. It would therefore be expected that the amount of free ammonia would be greater in the effluent than in the crude sewage, and Rideal states,* that, on the average, about 33% more free ammonia is found in the effluent than in the raw sewage. This is evidently based on his own experiment with a closed septic tank at Exeter. He found as the average of a series of analyses 3.6 parts of free ammonia in the sewage and 4.9 in the effluent. Perkins, working with the same average but at another time, obtained as the average of three samples 4.6 parts free ammonia in the sewage and 7.5 parts in the effluent, an increase of about 53%.

On the other hand, Dibden and Thudicum,† working on the same sewage, obtained as the average of 13 experiments less ammonia in the effluent than in the sewage, the loss equaling 26%, and Pearmain and Moore,‡ as the average of six analyses, a loss equaling 49%. Harrison, of Leeds,§ also reports that the amount of free ammonia in the sewage at Leeds averages 2.22 parts in 100,000 and in the effluent from the septic tank 1.74 parts, a decrease of nearly 22%. Clark,‖ in his experiments at Lawrence, found, in 1898, an increase of free ammonia of 8.6%, in 1899 of 15.47, while in 1900 there was apparent loss of 7.6% of free ammonia.

The results obtained by us on weekly analysis made of half-hour samples gave, as shown in the table below, an increase of about 20%, and though the increase is smaller in some months than in others there was not a single month when the effluent contained less ammonia than the raw sewage.

The difference in the amount of free ammonia found in the effluent of the septic tank by different observers is undoubtedly due to a great extent to the condition of the sewage as it enters the tank. The older the sewage the less would be the amount of free ammonia formed, yet a loss of 49% between the amount of free ammonia in the sewage and the effluent is not easily explained.

ALBUMINOID AMMONIA.—The difference in the amount of albuminoid ammonia in the sewage and in the effluent is usually taken as the measure of the organic matter that has been removed by a given process of sewage purification.

The results obtained in England with the septic tank range from 17½% found by Dibden and Thudicum in their Exeter experiment, to 59% obtained by Harrison with the closed tank at Leeds. The difference in these results is shown to be partly due to the amount of organic matter in the sewage; the greater percentage purification taking place with the stronger sewage. Rideal gives as the average amount of purification taking place in the septic tank, judged from the albuminoid ammonia, about 46%.

All these results are based on a rather limited number

*Sewage, and the Bacterial Purification of Sewage. Rideal. John Wiley & Sons. First Edition, p. 218.

†Purification of Sewage and Water. Sanitary Publishing Co., London, p. 76.

‡Report on the Septic Tank Process of Sewage Treatment, p. 10.

§Journal of the Society of Chemical Industry, 1900, p. 512.

‖Annual Reports of the Mass. State Board of Health, 1898, p. 438; 1899, p. 418; 1900, p. 372.

TABLE II.—SEPTIC TANK RESULTS GIVEN IN THE REPORTS OF THE MASSACHUSETTS STATE BOARD OF HEALTH. (Parts per 100,000.)

Months. 1898.	Temperature, °F. Sewage.	Temperature, °F. Effluent.	Free ammonia. Sewage.	Free ammonia. Effluent.	Albuminoid ammonia. Total. Sewage.	Total. Effluent.	Total. Removed %	Soluble. Sewage.	Soluble. Effluent.	Soluble. Removed %	Suspended. Sewage.	Suspended. Effluent.	Suspended. Removed %
January	..	52	....	4.16	....	0.34	.....	....	0.28	.....	....	0.06	.....
February	..	51	....	5.03	....	0.40	.....	....	0.32	.....	....	0.08	.....
March	..	48	....	4.89	....	0.48	.....	....	0.37	.....	....	0.11	.....
April	..	45	4.04	5.13	1.18	0.55	53.38	0.72	0.40	44.44	0.46	0.15	67.39
May	..	52	4.40	5.21	0.88	0.47	46.59	0.52	0.37	28.85	0.36	0.10	72.23
June	..	66	4.38	4.87	0.74	0.33	55.42	0.44	0.28	36.36	0.30	0.05	83.33
July	..	72	4.00	4.48	0.69	0.34	50.74	0.41	0.27	34.14	0.28	0.07	74.99
August	..	72	3.83	4.15	0.58	0.31	46.56	0.34	0.24	29.41	0.24	0.07	70.82
September	..	66	4.63	5.10	0.64	0.43	32.81	0.38	0.27	28.95	0.26	0.16	38.46
October	..	60	4.80	4.97	0.70	0.39	44.29	0.42	0.29	30.95	0.28	0.10	64.28
November	..	48	5.23	5.36	0.86	0.45	47.67	0.51	0.37	27.45	0.35	0.08	77.14
December.	..	49	4.02	4.92	0.84	0.44	47.62	0.50	0.34	32.00	0.34	0.10	70.58
Mean	..	57	4.44	4.86	0.79	0.412	47.85	0.47	0.32	31.92	0.32	0.09	71.88
1899.													
January	..	50	....	4.40	....	0.43	.....	....	0.32	.....	....	0.11	.....
February	..	48	....	4.35	....	0.39	.....	....	0.33	.....	....	0.06	.....
March	48	48	2.59	3.93	0.52	0.41	21.15	0.30	0.32	— 6.67	0.22	0.09	59.09
April	47	52	4.03	4.37	0.46	0.30	34.77	0.26	0.27	— 3.846	0.20	0.03	85.00
May	56	58	3.64	4.56	0.40	0.33	17.50	0.24	0.26	— 8.333	0.16	0.07	56.24
June	68	69	3.16	3.81	0.57	0.19	66.67	0.15	0.16	— 6.667	0.42	0.03	92.87
July	74	75	0.56	1.07	0.83	0.08	90.36	0.07	0.06	14.29	0.76	0.02	97.36
August	70	71	1.73	2.31	0.61	0.12	80.34	0.10	0.10	0.00	0.51	0.02	96.07
September	65	65	4.83	4.83	1.19	0.39	67.23	0.37	0.29	21.62	0.82	0.10	87.80
October	57	56	3.56	3.49	0.89	0.31	65.16	0.26	0.11	57.69	0.63	0.20	68.26
November	47	48	5.14	5.04	1.42	0.49	65.49	0.39	0.37	51.38	1.03	0.12	88.35
December	46	48	5.67	6.24	1.96	0.65	66.83	0.49	0.40	18.37	1.47	0.25	83.01
Mean	58	57	3.40	4.03	0.89	0.34	61.80	0.26	0.25	3.84	0.63	0.09	85.72
1900.													
January	42	46	4.86	4.34	1.49	0.51	65.77	0.39	0.36	7.691	1.10	0.15	86.36
February	39	43	3.23	2.74	0.67	0.28	58.22	0.24	0.26	— 8.333	0.43	0.02	95.35
March	41	43	3.25	2.66	1.50	0.28	81.34	0.22	0.22	0.00	1.28	0.06	95.32
April	47	47	5.18	4.75	1.02	0.47	53.93	0.37	0.32	13.52	0.65	0.15	76.93
May	53	55	4.93	4.72	0.87	0.36	58.62	0.31	0.25	19.32	0.56	0.11	80.35
June	65	66	4.80	4.38	0.57	0.41	28.06	0.24	0.21	12.05	0.33	0.20	39 40
July	74	73	6.12	5.34	0.83	0.25	69.87	0.51	0.13	75.37	0.32	0.12	62.50
August	74	72	5.68	5.12	0.69	0.32	53.63	0.32	0.15	53.13	0.37	0.17	54.80
September	70	68	5.63	5.25	0.80	0.33	58.75	0.34	0.19	44.12	0.46	0.14	69.55
October	65	61	6.30	5.00	1.15	0.35	69.56	0.52	0.22	57.69	0.63	0.13	79.38
November	52	52	5.20	5.70	1.18	0.45	61.86	0.41	0.28	31.71	0.77	0.17	77.93
December	39	47	4.65	5.30	0.98	0.66	32.65	0.54	0.42	22.22	0.44	0.24	45 44
Mean	55	56	4.99	4.61	0.98	0.39	60.22	0.37	0.25	32.43	0.61	0.14	77.05

TABLE III.—Reduction of Free and Albuminoid Ammonia in Worcester Sewage, 1900-1901.
(Parts per 100,000.)

Months.	Temperature, °F.		Gas,	Free ammonia.		Albuminoid ammonia								
						Total.			Soluble			Suspended		
	Sewage.	Effluent.	cu. ft. per day.	Sewage.	Effluent.	Sewage.	Effluent.	Removd %.	Sewage.	Effluent.	Removd %.	Sewage.	Effluent.	Removd %.
1900.														
October	67.1	65.4	9.09	1.43	1.88	0.6641	0.3850	36.26	.....	.....	.....	.....	.....	.....
November	61.9	57.8	6.43	1.575	2.225	0.7250	0.4325	40.34	.....	.....	.....	.....	.....	.....
December	52.6	51.0	2.95	1.605	1.862	0.5127	0.3114	39.25	.....	.....	.....	.....	.....	.....
1901.														
January	51.5	51.4	0.59	2.86	2.88.	0.8801	0.5630	39.03	.....	.....	.....	.....	.....	.....
February	50.0	....	0.69	3.04	3.14	0.702	0.692	9.18	.....	.....	.....	.....	.....	.....
March	48.5	48.0	0.30	2.25	2.20	0.579	0.550	5.08	.....	.....	.....	.....	.....	.....
April	49.0	48.0	0.80	1.17	1.35	0.46	0.381	17.37	.....	.....	.....	.....	.....	.....
May	54.8	54.7	2.89	1.22	1.48	0.362	0.266	25.57	.....	.....	.....	.....	.....	.....
June	59.2	60.0	8.12	1.60	1.96	0.511	0.435	14.87	.1990	.165	17.08	.3646	.2380	10.06
July	72.6	72.5	24.21	1.365	1.90	0.612	0.475	22.39	.1625	.14875	8.46	.4845	.3640	24.85
August	75.1	75.0	14.55	1.157	1.791	0.579	0.375	35.23	.19125	.1225	35.95	.3245	.2840	12.48
September	68.0	67.8	13.08	1.992	2.625	0.788	0.517	34.40	.3690	.2490	32.53	.4752	.2452	48.40
October	64.0	62.8	12.17	2.25	2.82	0.772	0.531	31 22	.2357	.1837	22.06	.5365	.3472	35.28
November	56.1	54.1	11.65	2.69	3.35	0.980	0.767	21.74	.366	.2380	34.97	.6130	.529	13.71
December	....	....	1.67	1.625	2.487	0.60	0.491	18.17	.211	.234	—10.90	.389	.253	34.96
Mean	....	....	7.28	1.855	2.263	0.6484	0.4781	26.25	.2478	19156	.22.70	.441	.3229	26.79

of analyses and the best published work on this subject is that of Clark in the reports of the Massachusetts State Board of Health, 1898, 1899 and 1900.

It should be noted that in the tank used by Clark from 1897 to Jan. 1, 1900, the sewage did not run continuously through the tank and that the sewage was only added to the tank at periods when the effluent was drawn off by means of a faucet. The results for 1900 were obtained from a remodelled tank where the flow of the sewage was continuous, thus representing more nearly the conditions found in actual practice. The tank was, however, a small one holding only 250 gallons, and it is not stated how many analyses were made each month or how the sampling was accomplished.

In studying these tables it is seen that the average removal of organic matter equalled in 1898 47%, in 1899 and 1900 about 60%; that as a rule the stronger the sewage the greater was the percentage of organic matter destroyed, and the percentage of organic matter decomposed during the warmer months was greater than in the colder months. There are, however, striking exceptions to both these rules: Thus in April, 1899, the total albuminoid ammonia equalling 0.46 parts in 100,000 and the temperature of the sewage averaging 47°, the amount of purification equalled 34.7%, while in May of the same year, the albuminoid ammonia equalling 0.40 parts and the temperature equalling 56°, the amount of purification was only 17½%, and in June, 1899, albuminoid ammonia in sewage being 0.57 parts and the temperature 68°, the amount of purification equalled 66½%, while in the same month of 1900, with the same amount of albuminoid ammonia in the sewage as in 1899 and a temperature of 65°, the purification only amounted to 28%.

As to the amount of decomposition of the organic matter in solution and suspension, judged from the albuminoid ammonia, the results obtained in 1899 are very different from results obtained in 1900. In 1899 3.8% of the organic matter in solution and 85.72% of the suspended organic matter was seemingly removed; while in 1900 the amounts are 32.43 and 77.05%, respectively. In 1899 the greatest amount of suspended organic matter was removed during the warmer months, July and August, 97.3 and 96%, respectively. In 1900 the largest amount was removed in January, February and March, 86.3, 95.35 and 95.32%.

The results that we have obtained are given in Table IV., where, besides the usual data, we have also given the average amount of gas given off from the tank per day each month.

The average amount of organic matter removed during the 15 months experiments with Worcester sewage, judged from the albuminoid ammonia, equalled only 26%. This, though larger than that obtained by Dibden with Exeter sewage, is much less than that usually obtained and is about one-half that obtained by Clark at Lawrence. This low percentage is partly due to the sewage containing less organic matter than average sewage, yet a careful study of the table indicates, we believe, that it is owing principally to the acid character of Worcester sewage and points to the fact that a less degree of purification is to be looked for from septic action on manufacturing sewage than from septic action on domestic sewage.

The same general rule shown in Mr. Clark's work is also shown in the above table, namely, that both the strength of the sewage and the temperature of the sewage have an effect on the amount of purification that takes place. There are, however, exceptions and results as difficult to explain in the data we have obtained as in Mr. Clark's data. The results* for December, 1900, when compared with the result for June, 1901, are not easily accounted for and show that much work remains to be done.

The amount of gas evolved seems to be in no direct ratio to the amount of albuminoid ammonia removed.

The determinations of dissolved and suspended albuminoid ammonia that we have made only extend over a period of six months and the data are not sufficient from which to draw any definite conclusions.

EVOLUTION OF GAS IN THE SEPTIC TANK.—Very few measurements of the amount of gas evolved in the process of decomposition that takes place in the septic tank have been made. Fowler, at Manchester, suspended a circular sheet-iron gas holder, 3 ft. in diameter, in an open septic tank, and noted the rate at which it rose and estimated from these measurements that when the tank was in full activity about 1 cu. ft. of gas was evolved from 100 gallons of sewage.†

Clark‡ measured the amount of gas evolved by closing the petcocks at the top of the compartments of the tank, allowing the gas evolved to collect in the tank, and measuring the volume by determining the volume of sewage required to replace this volume, noting the pressure exerted by the sewage and its temperature. Clark's statement regarding these measurements is:

These measurements resulted as follows, each covering a period of 24 hours, except in a few instances, when the period was 48 hours:

	Temperature, °F.		Gallons gas per 100 gallons of sewage passing through tank
	Air.	Sewage.	
10 measurements between April 21 and May 1, inclusive..	54	51	4.6
14 measurements between May 2 and May 22, inclusive..	55	52	6.3
22 measurements between July 10 and July 20, inclusive.	80	74	8.4

During the third period measurements were made covering two periods in each 24 hours, from 8 a. m. to 4 p. m. and from this hour to 8 a. m. Measuring in this way, it was found that during the night, when the flow of sewage was less under control and a smaller volume per hour passing through than in the day time, the volume of gas evolved equalled 13 gallons per 100 gallons of sewage, compared with 5.5 gallons during the period from 8 a. m. to 4 p. m. During October a few similar measurements were made, covering a period of 24 hours, and resulted as follows:

Temperature, ° F.	Air	65
	Sewage	65
Gallons of gas per 100 galls. of sewage through tank		4.5

Measurements at this time covering different periods of the day showed the same comparative results as during July.

From the above statements it would appear that the maximum amount of gas evolved per 100 gallons of sewage, as found by Mr. Clark, was twice that obtained at Manchester, while the mean of Mr. Clark's measurements agrees quite closely with Mr. Fowler's estimate.

In our work a standard gas meter was connected to one end of the gas outlet tube of the tank, the petcock of which was always left open, and the readings of the meter were taken every day at noon. The amount of sewage passing through the tank equalled 2,350 gallons per day.

The results by months are shown in Table IV.

The average amount of gas given off per 100 gallons of sewage, taking the whole 15 months, was 2.32 gallons; for the twelve months, October, 1900, to October, 1901, 2.2 gallons; and for the twelve months from January, 1901, to January, 1902, it was 2.4 gallons. This is about one-third of the amount obtained by Mr. Clark as the average of his determinations.

The tabulated results also show that the amount of gas evolved depends very greatly on the temperature, or that the amount of sludge decomposed is much greater in the warm than in the cold months, and that no accurate, or even an approximate, idea as to the amount of gas evolved can be obtained from a short series of experiments. In July, for instance, when the largest amount of gas was given off—1.03 cu. ft. per 100 gallons of sewage—the result agrees closely with Mr. Fowler's estimate of the amount given off at Manchester when the tank was in full activity. In the winter and spring months the amount of gas given off is so small in amount as to show that during that period very little of the solid matter in the tank was removed by being changed into gas.*

TABLE IV.—Production of Gas in Experimental Closed Septic Tank at Worcester, Mass.

	Temperatures.		Gas, cu. ft., in average per day.	Gas, in galls. per 100 gallons sewage.
	Sewage.	Effluent.		
October	67.1	65.4	9.15	2.912
November	61.9	57.8	6.43	2.046
December	52.6	51.0	2.95	0.9389
January	51.5	51.4	0.59	0.1878
February.	50.0	....	0.69	0.2196
March	48.5	48.0	0.30	0.0954
April	49.0	48.0	0.80	0.2546
May	54.8	54.7	2.89	0.9198
June	59.2	60.0	8.12	2.584
July	72.6	72.5	24.21	7.705
August	75.1	75.1	14.55	4.631
September	68.0	67.8	13.08	4.162
October	64.0	62.8	12.17	3.873
November	56.1	54.1	11.65	3.709
December	48.15	49.3	1.80	0.5729
Mean	58.57	58.41	7.292	2.320

*The results that Mr. Clark and we have obtained may indicate that the methods of sampling employed are far from correct, and it seems to us that this very important question, entering as it does into all sewage work, should receive the most serious attention of all sanitary chemists.

†The amount of gas evolved from the tank in the warm months must depend much more on the quantity and character of the sludge in the tank than on the quantity of sewage passing through the tank, and the stating of the amount of gas given off, as a given amount per 100 gallons of sewage, while most convenient for comparison, is evidently misleading.

‡Thirty-second Annual Report of Massachusetts State Board of Health, p. 373.

COMPOSITION OF THE GAS PRODUCED BY THE BACTERIAL ACTION IN THE TANK.

Rideal gives as the percentage composition of the gas from the closed septic tank at Exeter, carbon dioxide, CO_2, 0.6; methane, CH_4, 24.4; hydrogen, H, 36.4; nitrogen, N, 38.6.

Fowler gives as the approximate analysis of the gas from the septic tank at Manchester, carbon dioxide, CO_2, 6.0; methane, CH_4, 73.0; hydrogen, H, 5.0; nitrogen, N, 16.0.

Gill† analyzed the gas from the experimental tank at Lawrence and obtained, carbon dioxide, CO_2, 3.4; illuminants, C_nH_{2n}, 0.3; oxygen, O, 0.5; carbon monoxide, CO, 0.6; methane, CH_4, 78.9; nitrogen, N, 16.3.

We have made a special study of the gases formed in the tank by the action of bacteria on the organic matter. Samples of the gas have been taken each week, except during the months of January, February and August, and analyzed.

As may be seen from Table V., we have never been able, with Worcester sewage, to obtain results comparable to those given by Dr. Rideal as the composition of the gas given off from the septic tank at Exeter. The smallest amount of carbon dioxide found by us in any analysis was 2%, while the largest amount ever obtained equals 22%. Hydrogen was found only in a very few cases, and the amount was always under 4%, and the cases were so very few in which the analysis gave any hydrogen that we are inclined to believe that possibly the result was due to errors caused by too violent explosions of the gas mixture.

We have also never been able to confirm Professor Gills' result as to the presence of carbon monoxide. Sulphate of hydrogen we have not yet detected in the gases from the septic tank.

THE AMOUNT OF SLUDGE CONVERTED INTO SOLUBLE OR GASEOUS SUBSTANCES.

There can be no question that a certain amount of the solid matter arrested by the passage of sewage through a septic tank is converted into soluble and gaseous substances. The amount that is so converted evidently depends to a large degree on the composition of the substances deposited in the tank.

Dibden, from his work at Exeter, and Harrison, as a result of his experiments at Leeds, give the amount, as about 70%. Fowler, in the last report of the work at Manchester, gives it as about 40%, which was also the results obtained by Campbell,‡ Borough Engineer at Huddersfield. Carpenter,§ from his work at Pawtucket, R. I., found the amount to be equal to 47%.

At Worcester we find the amount of sludge destroyed to equal only 28%. This result was obtained from the following data:

Total volume of sewage run through the tank from the time the tank was first placed in operation, July 9, 1900, to Oct. 29, 1902, 1,036,350 gallons.

Suspended matter in grains per gallon arrested by passage of sewage through the tank, 3.61, or a total of 534.4 lbs.

Depth of sludge in tank Oct. 29, 1902, 16¼ ins., equaling 59.102 cu. ft.

TABLE V.—Composition of Gases from Experimental Closed Septic Tank at Worcester, Mass.

Months.	Carbon dioxide, CO_2.	Oxygen, O.	Absorbed by cuprous chloride.	Methane, CH_4.	Nitrogen, N.
October	5.6	1.9	0.8	75.3	16.4
November ..	4.1	1.2	0.5	76.9	17.3
December ..	2.5	2.0	0.4	69.5	25.6
March	8.8	1.0	0.1	13.3	76.8
April	9.8	0.9	0.2	28.4	60.7
May	15.2	1.5	0.1	26.9	56.3
June	17.0	1.2	0.2	52.1	29.5
July	8.7	1.3	0.4	63.8	25.8
September ..	8.0	1.6	0.4	57.8	32.2
October	6.9	0.6	0.6	72.4	19.5
November ..	6.3	0.7	0.3	79.2	13.5
December ..	5.6	0.9	0.1	76.8	16.6
Mean	8.2	1.2	0.34	57.7	32.5

*The very low results we obtained for January, February and March may possibly be due partly to the fact we have already mentioned, i. e., the high acidity of the sewage at one time in the month of January, and it is also possible that full septic action had not begun before cold weather.

†Annual Report, Massachusetts State Board of Health, 1899, p. 422.

‡London "Surveyor," Sept. 6, 1901.

§Engineering News, 1902, July-December, p. 478.

TABLE VI.—Composition of Sludge from Experimental Closed Septic Tank at Worcester, Mass.

	1901.		
	Jan. 4.	May 7.	Oct. 22.
Specific gravity	1.039	1.041	1.043
Solids, %	8.73	9.70	9.93
Water, %	91.27	90.3	90.07
Composition of sludge:*			
SiO_2	22.74	17.55	22.70
FeS	11.64	11.61	19.54
Fe not united to S	3.04	3.59	4.03
S not as sulphide	0.10	0.19	....
Al_2O_3	8.78	7.40	7.00
CaO	0.64	0.50	1.62
MgO	....	....	0.67
P_2O_5	....	....	1.58
C	24.83	30.52	19.83
H	3.73	4.67	2.94
N	2.78	4.30	2.30

*Percentage calculated from analyses of moist sludge.

Specific gravity of sludge, 1.043.

Dry solid matter in sludge, 9.97%, having a total weight of 384.1 lbs.

Solid matter converted into soluble or gaseous substances, 148.6 lbs., or 28.13% of the total suspended matter arrested.

This is a smaller amount than has been previously reported, and it is undoubtedly owing to the fact that the sludge contains, besides sand and clay, a large amount of iron sulphide, and it shows that with iron acid sewage the clearing out of the sludge from the septic tank will be of much more frequent occurrence than with ordinary domestic sewage.

THE CHEMICAL COMPOSITION OF THE SLUDGE.—The composition of the sludge must depend, to a great degree, on the composition of the sewage, whether or not storm water enters the sewers, and also whether or not catch-basins are used in which sand and heavy substances are deposited, and also on how thoroughly the sewage is screened before entering the tank.

In the closed tank at Worcester there is a catch-basin, and also the sewage, as has been said, is passed through an iron screen with bars ½-in. apart, which prevents paper and large floating substances from entering the tank.

Analyses of the sludge, Table VI., taken from the tank at three different seasons give a fair idea of its composition and seem to show that the sludge in May contains a larger proportion of organic matter than it does at the end of the summer or autumn months.

THE CRUST.

The formation of a crust on the surface of the liquid in a septic tank was formerly believed to take place in all cases, and it was considered that true septic action had not begun till this crust began to form, and that septic action could be started in a new tank by adding to the liquid in the tank the crust from an old tank.

These views have been modified during the past few years, as in many cases no permanent crust is formed on the surface, only a slight scum over parts of the tank, which a moderate breeze would disperse, and it seems that a crust is not a necessity, but rather an incident, in the liquefaction of solids that takes place in the tank.

At Worcester the open septic tank is at times completely covered with a crust; at other times the crust covers only a small portion of the liquid.

In the experimental closed septic tank a crust began to form when the tank first started, which gradually increased in thickness, till, in November, 1900, it measured 1½ ins. On Jan. 4, 1901, on opening the tank, it was found that the crust had disappeared, but on the next opening of the tank, Feb. 26, it was found that a crust had again formed, measuring 1 in. in thickness. On May 7 it was 1¾ ins. thick. The tank was not opened again until October, at which time the crust had entirely disappeared, and up to the present time there has been no reformation of the crust.

The analysis of a sample of the crust, taken from the closed septic tank February, 1901, gave the following result, in percentages:

Silica, SiO_2, 12.62; iron sulphide, FeS, 8.93; iron, Fe (not united to sulphur), 1.61; sulphur, S, not as sulphide, 0.00; alumina, Al_2O_3, 12.62; lime, CaO, 4.23; carbon, C, 41.83; hydrogen, H, 6.51; nitrogen, N, 5.20.

The formation, non-formation and disappearance of the crust are phenomena for which we have no explanation.

GENERAL CONCLUSIONS.

Though we consider this paper as a preliminary one, principally a record of data obtained during the past 15 months, and though the observations and experiments of the next year may change or modify some of the results, we think the results so far obtained point to the following conclusions as to the action of a septic tank on an acid iron sewage similar to Worcester sewage:

That about one-fourth of the total solid matter is removed by the passage of the sewage through a septic tank.

That the amount of soluble matter removed, equalling in Worcester about 21% of the total soluble matter, is greater than the amount usually found to be removed from a sewage by septic tank action.

That the amount of suspended matter removed, found to be about 25% of the total suspended matter, is very much less than the amount removed by the same process from a sewage containing less manufacturing waste.

That the above results are due to the change of the soluble sulphate of iron in the sewage into the insoluble sulphide of iron, and to the fact that a comparatively large amount of iron sulphide is carried out of a septic tank in the effluent.

That the action of a septic tank removes a large amount of iron from an acid iron sewage.

That the amount of organic matter removed, 26% in Worcester sewage, is much less than is removed by the same process from an alkaline domestic sewage.

That though a greater amount of organic matter seems to be removed from the sewage in the warm months than in the cold months, the results, possibly owing to methods of sampling, show no direct relationship between the organic matter removed and the temperature.

That the amount of gas given off depends greatly upon the amount and character of the sludge at the bottom of a tank, and the amount given off is a measure of the total amount of bacterial action taking place, and is not a measure of the amount of organic matter being removed at any given time from the sewage.

That the amount of gas evolved from a septic tank depends upon the temperature, and that it is less in winter than in summer.

That the amount of gas evolved from the septic tank at Worcester for the past year, 2.2 gallons per 100 gallons of sewage passing through the tank, is probably less than would be obtained from a tank where the sludge contains a greater amount of organic matter.

That the gas given off from a tank through which acid iron sewage is passing is a mixture of methane, nitrogen, and carbon dioxide, containing little, if any, hydrogen.

That the amount of sludge changed into soluble or gaseous substances, 28% with Worcester sewage, is probably less than would usually be the case, on account of the large amount of iron sulphide in the sludge.

That the sludge in a septic tank contains less organic matter in the autumn than in the spring.

That the crust contains a much larger amount of organic matter than the sludge.

That the formation, non-formation and disappearance of the crust on top of the liquid in a septic tank appears to be an incident rather than a result of bacterial action.

THE MINES AND METALLURGY BUILDING AT THE ST. LOUIS EXPOSITION.

We have received from the Publicity Department of the Louisiana Purchase Exposition the photograph herewith reproduced of the architect's design for the Mines and Metallurgy Building, at the St. Louis Exposition. The building is to cover an area 525 × 750 ft. in size, and will furnish an exhibition space of about 265,000 sq. ft., which may be increased about 150,000 sq. ft. by the addition of galleries.

Concerning the architectural features of the design we cannot do better than quote verbatim from the description sent up by the Publicity Department as follows:

As a building for housing exposition exhibits [illegible] argued that it should express externally as much [illegible] dignity as would be compatible with its ephemeral character; that it would be incongruous, however, to [illegible] guise its ephemeral character by the garb of severe [illegible] classic forms which we associate with the most [illegible] architectural monuments of antiquity; and that, furthermore, being a part of the greatest exposition ever attempted, it undoubtedly should be novel, striking and full of life.

The style of architecture which it represents has been a source of much speculation. Mr. Theo. C. Link, the architect of the building says:

Some have attempted to classify it as an example of the "nouveau;" but when I recently noticed an English critic say, in protesting against its invasion of Great Britain, that this "nouveau art" is "a malady, the pernicious virus of which becomes more acute the farther it travels," I feel a strong personal solicitude for

THE FACADE FOR THE MINES AND METALLURGY BUILDING AT THE ST. LOUIS EXPOSITION.

properly conducted baptismal ceremony. Let us therefore name it Secession Architecture. Perhaps I will have to explain what Secession Architecture is, if the name should not make it quite clear. It means architectural liberty and emancipation with a strong plea for individuality. It is a breaking away from conventionality in design; it is more an architecture of feeling than of formula.

If we were to engage in speculation as to the style of architecture which this remarkable design represents, we would suggest that as Ionic pilasters, and Doric columns unite to support a Spanish roof, surmounted by a dome of Renaissance effect, while Egyptian monoliths guard the entrance to a doorway ornamented by Grecian fretwork, and a number of additional styles have evidently "felt" their way into the composition, it would be more appropriate to call it mongrel architecture.

Speaking seriously, it would be a thousand pities if the vast amount of money which is to be expended at St. Louis should go for the production of such architectural monstrosities as this. It has often been said that the Chicago Exposition was fully justified by its vast educational influence in disseminating sound ideas of architectural beauty. There is no reason why St. Louis might not achieve an equal architectural success, by summoning, as Chicago did, the ablest architects and artists of the country to her aid. To attempt to succeed by departing from all recognized laws of artistic design may result in "novel and striking" forms, but nothing can be produced in this way which will receive the world's admiration as did the famous "White City" on the shore of Lake Michigan.

Mr. Link's choice of a name for his style appears to us even more appropriate than he intended. History records that it was not Secession but adherence to law that brought Liberty and Emancipation. Judging by the photograph before us, Secession in architecture appears to breed results bordering on anarchy.